No. 6 and No. 8 ET Brake Equipment

By

J. W. HARDING

DIRECTOR, SCHOOL OF STEAM RAILROADS

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
Parts 1-2

NO. 8 ET LOCOMOTIVE BRAKE EQUIPMENT

515D

Published by
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.

Printed in U. S. A.

INTERNATIONAL TEXTBOOK PRESS
Scranton, Pa.

85043

CONTENTS

NOTE.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(PART 1)

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT (PART 2)

NO. 8 ET LOCOMOTIVE BRAKE EQUIPMENT

KEY TO COLOR PLATES

Red	*Main-Reservoir Pressure*
Pink	*Brake-Cylinder Pressure*
Dark Green	*Pressure-Chamber Pressure*
Blue Green	*Feed-Valve Pressure*
Light Green	*Equalizing-Reservoir Pressure*
Orange	*Atmospheric Pressure*
Yellow	*Brake-Pipe Pressure*
Blue	*Live Steam*
Purple	*Application-Chamber Pressure*
Gray	*Reducing-Valve Pressure*

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

Serial 5548A (PART 1) Edition 1

CONSTRUCTION AND OPERATION

PARTS OF APPARATUS

1. Development.—While the combined automatic and straight-air locomotive brake equipment provided independent control of the locomotive brake, and thus increased the flexibility of the brake in switching and in the control of trains on grades, yet these advantages were obtained only by a considerable increase over the number of parts comprising the A-1 engine equipment. In fact, from the adoption of the automatic brake, all improvements were made by the addition of apparatus to the already existing equipment; consequently, as the improvements progressed, the equipment became more and more complicated. When further improvements were contemplated, it was apparent that any further addition to the apparatus then in use would make the brake system too cumbersome. This situation naturally led to the design of a locomotive brake equipment that combined in one part the functions of several pieces of apparatus of the existing brake equipment, and included, in addition, the features necessary to meet the requirements of all classes of service.

2. This brake is known as the ET locomotive brake equipment, the letters ET being abbreviations for *engine* and *tender*, indicating that the one equipment is complete for both engine and tender, as the only air part required to operate the tender brake is its brake cylinder. The equipment was first introduced in 1905, and was known as the No. 5 ET equipment.

It was followed shortly after by the introduction of the No. 6 equipment, which was an improvement on the No. 5. This lesson will treat only of the No. 6 equipment.

3. **Brake Charts.**—Accompanying this lesson is a series of charts numbered 1 to 12, inclusive, which show a piping diagram and diagrammatic sectional views of the No. 6 ET brake equipment, in its various positions, the pressures in the various parts being indicated by different colors which have the significance indicated in the Key to Color Plates. A chart No. 13 showing transparencies of the H-6 and S-6 brake valves is also included.

4. **Names of Parts.**—The essential parts of the No. 6 ET equipment, as shown in Chart No. 1, are as follows: The air compressor; the main reservoirs; the steam compressor governor; the distributing valve with double chamber reservoir; an automatic brake valve with equalizing reservoir; an independent brake valve; a feed valve; a reducing valve, a brake pipe vent valve on the tender; an emergency relay valve; two centrifugal dirt collectors, one for the protection of the distributing valve and the other with a drain cock for the protection of the feed and reducing valves; a combined strainer and check-valve which with a cut-out cock constitutes the dead-engine fixtures; two duplex air gages; driver, tender, and truck brake cylinders; and the necessary piping and hose, with cocks and fittings, to make the connection between the parts.

5. **Purpose of Parts.**—The purpose of the parts other than those already found in other locomotive brake equipments is as follows:

The distributing valve applies the locomotive brake, or the brake on the engine and tender, the air supply for the brake cylinders being taken from the main reservoir; it also releases the brake by exhausting the air from the brake cylinders, and automatically prevents the pressure in the brake cylinders from being reduced by leaks when the brake is held applied.

The automatic brake valve controls the operation of the locomotive and the train brakes.

The independent brake valve, as the name implies, permits

the locomotive brake to be operated independent of the train brakes.

The reducing valve reduces the main-reservoir pressure to 45 pounds for the independent brake valve and for the air-signal system.

The duplex air gages provide a means of indicating main-reservoir and equalizing-reservoir pressures on gage No. 1, and brake-pipe and locomotive brake-cylinder pressures on gage No. 2.

The feed-valve, which is of the double-pressure type, maintains automatically the brake-pipe pressure desired when the automatic brake valve is in running and holding positions.

The brake pipe vent valve on the tender insures the transmission of quick action, that originates on the engine, to the train, or that originates on the train to the engine.

The emergency relay valve makes it possible to create an emergency rate of brake pipe reduction from the brake valve under all service conditions, as well as when the double-heading cock is closed. The dead-engine fixtures permits the brakes of a locomotive that is being hauled dead in a train to be operated the same as the brakes on the cars.

6. Advantages of ET Equipment.—As compared with previous equipments, the ET equipment has advantages in operation, in convenience in repairing, and also in economy of material.

The principal operating advantage is that the brake-cylinder pressure developed on the engine and tender, unlike earlier equipments, is not affected by leaks or piston travel. Therefore, brake-cylinder leakage will not cause the brake to leak off, neither will long piston travel lessen the braking pressure. The engineer has full control of the brakes on his engine at all times, whether on a helper engine or on an engine in charge of the train, and can increase or decrease the braking pressure without affecting the train brakes.

The equipment is convenient to repair, as no pipe joints have to be broken to remove the distributing valve, the brake valves, feed-valve, or reducing valve. Also, any of these parts can be

removed without stopping the compressor and draining the main reservoir.

The equipment is more economical of material, as fewer parts are used and the same set of parts and same size of parts answer for locomotives in all classes of service.

GENERAL ARRANGEMENT OF APPARATUS

7. Names of Pipes.—The names of the pipes and the parts connected by them are shown in the piping diagram, Chart No. 1.

The discharge pipe connects the air compressor to the first main reservoir.

The connecting pipe, also known as the radiating pipe, connects the two main reservoirs.

The main-reservoir pipe connects the last main reservoir to the automatic brake valve. This pipe has five branches to the following parts: Feed-valve, reducing valve, distributing valve, dead-engine fixtures, and to the No. 1 duplex gage.

Branch pipes not shown lead to various air-using devices such as sanders, fire-doors, reverse gears, etc.

The high-pressure operating pipe connects the main-reservoir connecting pipe to the high-pressure head of the governor.

The low-pressure operating pipe connects the automatic brake valve to the low-pressure head of the compressor governor.

The feed-valve pipe connects the feed-valve to the automatic brake valve, although in some installations the brake valve is provided with a pipe bracket to which the feed-valve is directly attached, thus eliminating the feed-valve pipe.

The reducing-valve pipe connects the reducing valve to the independent brake valve and to the signal system.

The brake pipe on the engine extends from the automatic brake valve to the angle cock on the tender, with a branch to the pilot, to the dead-engine fixtures, to the distributing valve, to the emergency relay valve, and to the No. 2 duplex air gage.

The pipe between the distributing valve and the brake pipe is known as the brake-pipe branch pipe.

The application-cylinder pipe connects the application cylinder of the distributing valve to the independent and the automatic brake valves.

The distributing-valve release pipe connects the application-cylinder exhaust port of the distributing valve to the independent brake valve.

The release pipe connects the independent brake valve to the automatic brake valve. This pipe is a continuation of the distributing-valve release pipe.

The brake-cylinder pipe connects the distributing valve with the driver, the tender, and the truck brake cylinders. The relay valve pipe connects the emergency relay valve to the sand pipe tap of the automatic brake valve.

The dead-engine fixtures connect the main-reservoir pipe with the brake pipe.

The brake-cylinder gage pipe connects the brake-cylinder pipe with the red hand of air gage No. 2. The brake-pipe gage pipe connects the brake pipe with the black hand of gage No. 2. The main-reservoir gage pipe connects the main-reservoir pipe with the red hand of gage No. 1.

The equalizing-reservoir gage pipe connects the equalizing reservoir with the black hand of gage No. 1.

The equalizing-reservoir pipe connects the automatic brake valve to the equalizing reservoir.

8. **Pipes at Distributing Valve and Brake Valves.**—The double-chamber reservoir of the distributing valve has five pipes connected to it, three being on the left and two on the right. Of the three pipes on the left, the upper one is the main reservoir supply pipe, the middle one is the application-cylinder pipe, and the lower one is the distributing-valve release pipe. The upper pipe on the right is the brake-cylinder pipe, and the lower pipe is the brake-pipe branch pipe. The independent brake valve has four pipes connected to it. Beginning at the right, they are the reducing-valve pipe, the application-cylinder pipe, the distributing-valve release pipe, and the release pipe. The automatic brake valve has eight pipes connected to it, the equalizing-reservoir pipe, the release pipe, the brake pipe, the application-cylinder pipe, the main-reservoir pipe, the feed-valve pipe, the low pressure operating pipe, and the emergency relay valve pipe.

MANIPULATION

9. Automatic Operation.—Following are given the necessary instructions for manipulating the No. 6 ET equipment:

When not in use, both brake-valve handles should be carried in running position. To apply the locomotive brakes and the train brakes in service, move the handle of the automatic brake valve to service position, and make the required brake pipe reduction, and then back to lap position to hold the brakes applied. The train brakes are released and the locomotive brake is held applied by moving the automatic brake valve to full-release position. To release the locomotive brake, the automatic brake valve must be placed in running position. Move the brake valve to holding position if it is desired to hold the locomotive brake applied for a period longer than the brake valve can be left in release position without danger of overcharging the brake pipe. The release of the locomotive brake may be graduated by moving the automatic brake valve between holding and running positions. To apply the brakes in emergency, move the handle of the automatic brake valve quickly to emergency position and leave it there until the train stops.

10. Independent Operation.—When the independent brake valve only is used, the handle of the automatic brake valve should be carried in running position. To apply the locomotive brake by means of the independent brake valve, move the valve to slow or quick application position until the desired brake-cylinder pressure is obtained, as indicated by the red hand on the No. 2 gage; then move the brake valve to lap. To release the locomotive brake, place the independent brake valve in running position. To release the locomotive brake after it has been applied by the automatic brake valve, place the independent brake valve in release position.

The independent brake valve should be placed and left in slow application position when the engine is standing at coal chutes, when men are working about the engine, or when the engine is to be left under steam. In this position, the brake is automatically held applied against leakage.

11. Double-Heading.—In double-heading or helper service, close the double-heading cock under the brake valve on all engines except the one from which the brakes are being operated, and keep both brake valves in running position. The brakes on the helper engines can be applied or released at any time by using the independent brake valve.

12. Dead Engine.—If an engine is being towed dead in a train, or has no air in its main reservoir because of compressor failure, place both brake valves in running position, close the double-heading cock, and open the cut-out cock in the dead-engine fixtures by turning the handle at right angles to the pipe.

NO. 6-E DISTRIBUTING VALVE

13. Purpose.—The purpose of the distributing valve is to apply the locomotive brake by admitting air from the main reservoir to the brake cylinders on the engine and the tender, to release the brake by exhausting the air from the brake cylinders, and to maintain automatically the pressure in the brake cylinders against leakage after brake applications. The distributing valve acts as a reducing valve when admitting air from the main reservoir to the brake cylinders, the pressure developed in the cylinders being then always less than main-reservoir pressure.

The distributing valve replaces the triple valves, auxiliary reservoirs, high-speed reducing valves, and double check-valves of other equipments and performs the function of these parts as well as other important functions not performed by them. The No. 6-E distributing valve differs from the No. 6 formerly used by having a $\frac{3}{64}$-inch instead of a $\frac{5}{64}$-inch service port, thereby requiring the employment of a heavier spring in the equalizing cylinder cap. The use of the smaller service port is to insure a build-up of pressure in the locomotive brake cylinders more nearly uniform with that of the brake cylinders on the cars. The spider end of the application piston has also been redesigned with the new valve.

14. Exterior Views.—Two exterior views of the opposite sides of the distributing valve and its double-chamber reser-

voir are shown in Figs. 1 and 2. The distributing valve is attached to the reservoir by four studs and nuts *36,* one of which is shown in Fig. 2. In Fig. 1, the distributing-valve

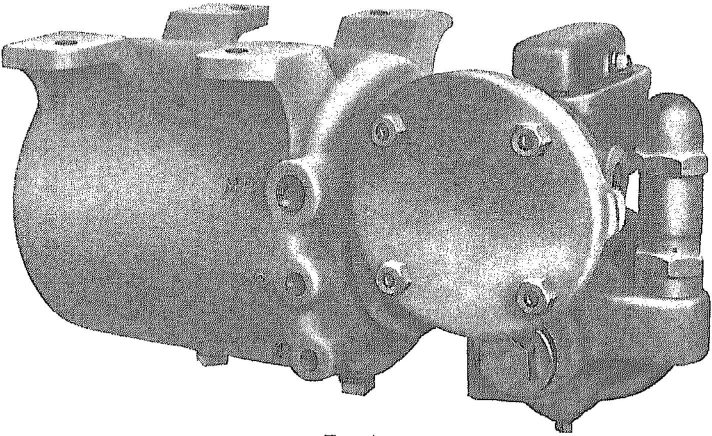


Fig. 1

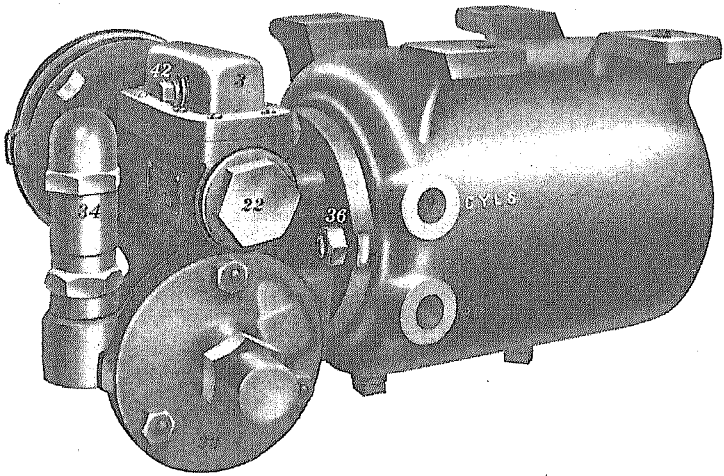


Fig. 2

supply pipe connects to the double-chamber reservoir at *MR,* the application-cylinder pipe at *2,* and the distributing-valve release pipe at *4.* In Fig. 2, the connection for the brake-cylinder pipe is at *Cyls.* and for the brake-pipe branch pipe

at *BP*. The references indicating the pipe connections are cast on the reservoir. All the pipe connections are made to the double-chamber reservoir, so that the distributing valve, which

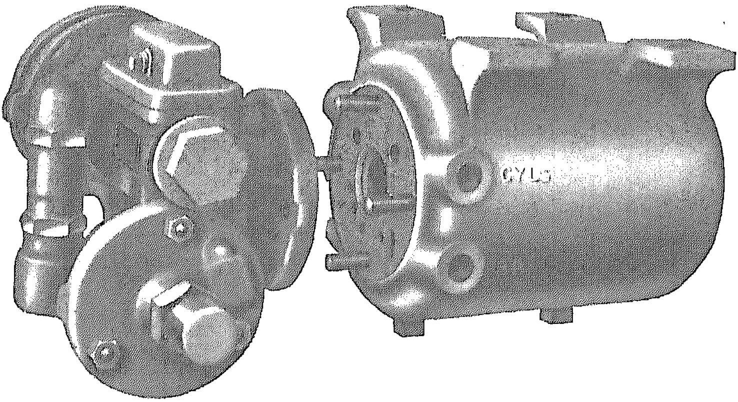


FIG. 3

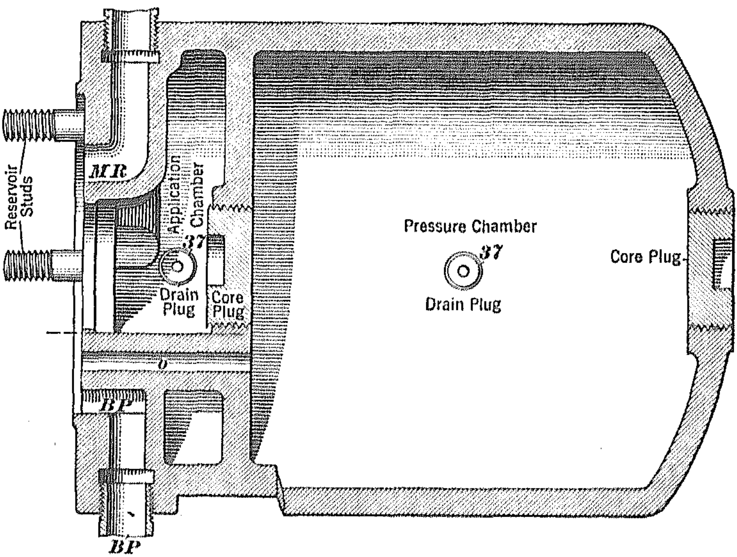


FIG. 4

contains all the moving parts, can be removed from the reservoir for repairs without interfering with the piping. In Fig. 3, the distributing valve is shown separated from the reservoir.

15. Sectional and Detached Views.—A section taken lengthwise through the double-chamber reservoir is shown in Fig. 4, the distributing valve being removed. The reservoir consists of two chambers, called the pressure chamber and the application chamber, the two being separated by a partition.

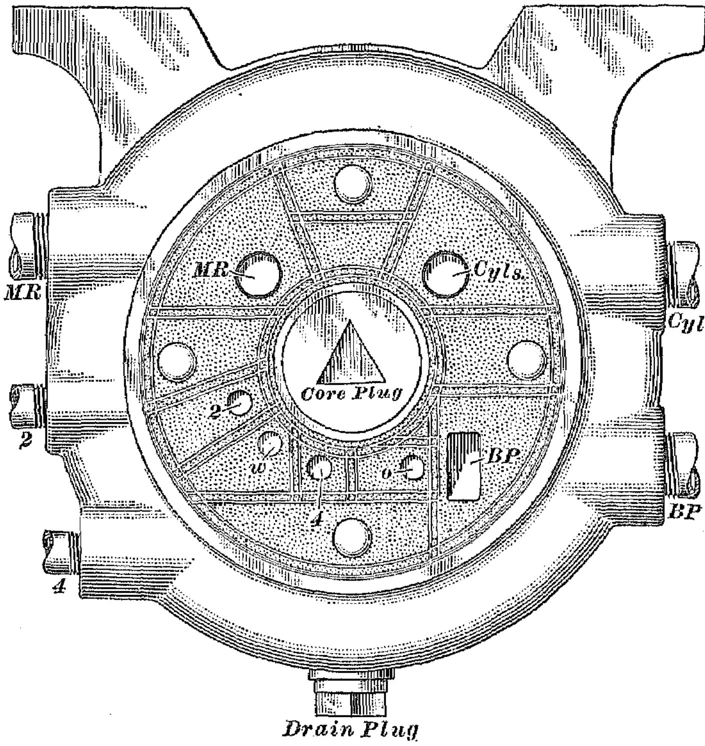


FIG. 5

The distributing valve forms a cap for the outer side of the application chamber when it is bolted to the reservoir. The pressure chamber is connected to the face of the reservoir by a passage *o*. Each chamber is provided with a drain plug *37*.

The core openings in the double-chamber reservoir are filled by core plugs. The passages *MR* and *BP* in the double-chamber reservoir, as well as passage *o*, register with corresponding passages in the distributing valve when the two parts are bolted together.

In Fig. 5 is a view of the distributing-valve face of the double-chamber reservoir, with the gasket in place. The large opening shown is merely for the purpose of inserting the core plug in the partition between the two chambers (see Fig. 4), and if it were not for this fact it could be omitted. The five pipe connections to the reservoir lead by interior passages to

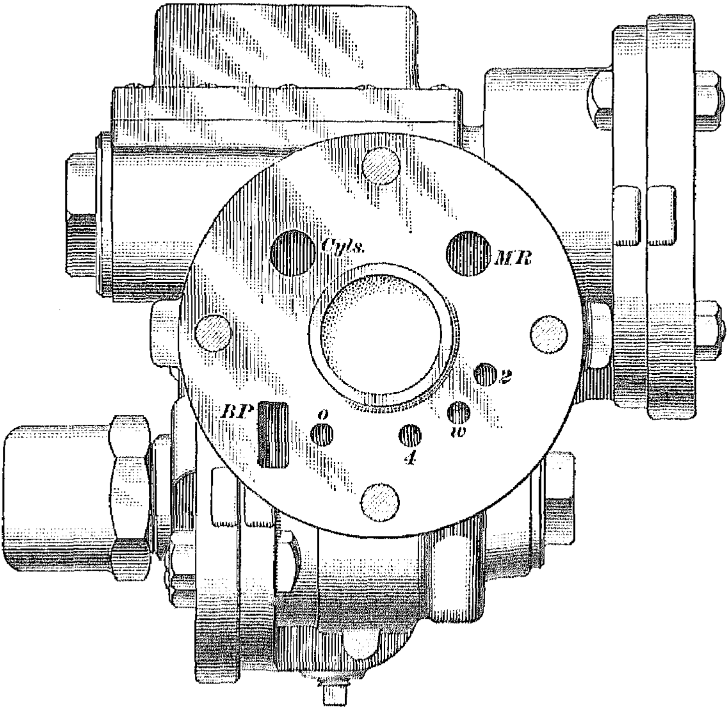


FIG. 6

ports that are similarly marked in the face of the reservoir. Port *w* leads into the application chamber, and port *o* into the pressure chamber.

A face view of the distributing valve detached from the double-chamber reservoir is given in Fig. 6. The ports shown register with ports that are similarly marked in the face of the double-chamber reservoir, Fig. 5, when the two parts are assembled.

16. Parts of Distributing Valve.—A section taken through the distributing valve, showing all the movable parts and also the application cylinder, is given in Fig. 7.

The numbers and names of the various parts of the distributing valve are as follows: *2,* valve body; *3,* application-valve cover; *4,* cover screw; *5,* application valve; *6,* application-valve

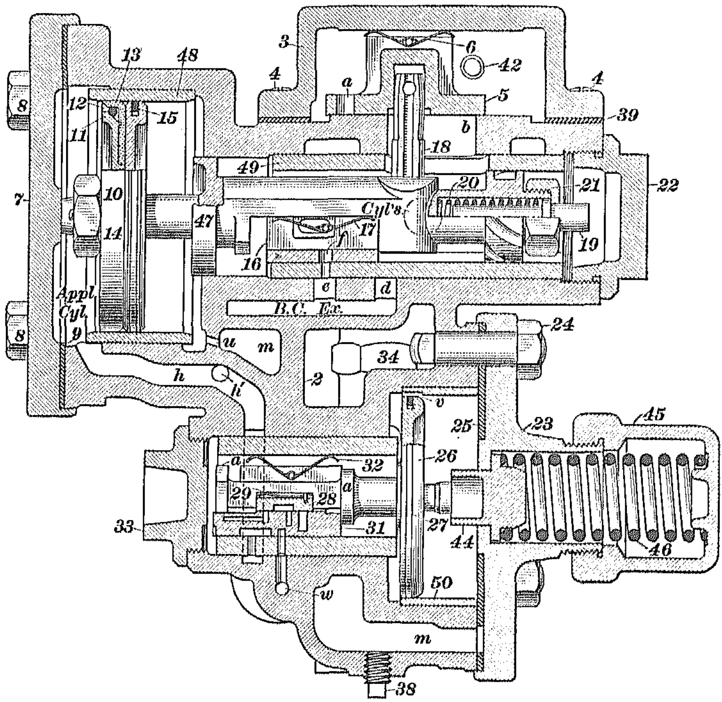


FIG. 7

spring; *7,* application-cylinder cover; *8,* cylinder-cover bolt and nut; *9,* cylinder-cover gasket; *10,* application piston; *11,* piston follower; *12,* packing-leather expander; *13,* packing leather; *14,* application-piston nut; *15,* application-piston packing ring; *16,* exhaust valve; *17,* exhaust-valve spring; *18,* application-valve pin; *19,* application graduating stem; *20,* application graduating spring; *21,* application graduating-stem nut; *22,* upper cap nut; *23,* plain-cylinder cap; *24,* bolt and nut; *25,*

cylinder-cap gasket; *26,* equalizing piston; *27,* equalizing-piston ring; *28,* graduating valve; *29,* graduating-valve spring; *31,* equalizing slide valve; *32,* equalizing slide-valve spring; *33,* lower cap nut; *34,* safety valve; *38,* distributing-valve drain plug; *39,* application-valve cover gasket; *42,* oil plug; *44,* graduating sleeve; *45,* cap nut; *46,* equalizing-piston graduating spring, and *47,* application-piston guide.

The distributing valve contains two distinct sets of movable parts, the lower part being called the equalizing portion and the upper part the application portion.

17. Purpose of Application Portion.—The purpose of the application portion of the distributing valve is to apply the locomotive brake, release the brake, and maintain, with the brake applied, a brake-cylinder pressure equal to that in the application cylinder.

18. Description of Application Portion.—The application portion, Fig. 7, consists of the application piston *10* and attached stem, with a graduating stem *19* and spring *20,* the application valve *5,* application-valve pin *18,* and exhaust valve *16.* The application piston operates within a brass bush *48,* and the exhaust valve within a brass bush *49.* The application valve is connected to the stem of the application piston *10* by the application-valve pin *18.* Any movement of the application piston is then communicated to the application valve, as the pin *18* can move to and fro in slot *b.*

The exhaust valve *16* is made shorter than the slot in the application-piston stem in which it operates, so that the application piston can move the application valve under certain conditions without moving the exhaust valve.

The chamber in which the application valve *5* operates is connected at all times to the main reservoir. The space behind the application piston and around the piston stem is connected to the locomotive brake cylinders through the opening *Cyls.* shown by the circle, as the application-piston guide *47* is not air-tight. Brake-cylinder air can also pass from passage *m* through port *u* to the space behind the piston. The space in front of the application piston *10* is the application cylinder.

The application piston is caused to work air-tight by a packing leather *13*, packing expander *12*, and packing ring *15*. The leather and the expander are secured to the piston by the piston follower *11* and the application-piston nut *14*.

Port *u* serves to drain any moisture from the space back of the application piston. The moisture passes to the lower part of the distributing valve through passage *m* and is drawn off by drain plug *38*. Port *h'* leads to the application cylinder pipe.

19. Purpose of Parts.—The purpose of the application valve *5*, Fig. *7*, is to admit air from the main reservoir through port *a* to the brake cylinders on the engine and tender and thus apply the brake.

The purpose of the exhaust valve *16* is to discharge the air from the brake cylinders on the engine and tender through ports *e* and *d* to the brake-cylinder exhaust port and thus release the brake.

The purpose of the application piston *10* is to operate the application valve and the exhaust valve. These valves are so connected to the stem of the application piston that the movement of the piston can (*a*) move the exhaust valve and cut off communication from the brake cylinders to the atmosphere before it moves the application valve far enough to open port *a*; (*b*) close both the application valve and the exhaust valve and thus hold the brakes applied; (*c*) open the exhaust valve and release the engine and tender brakes, while keeping the application valve closed.

The purpose of the application-graduating stem *19* and spring *20* is to move the application piston and valve to lap position, and also to prevent valve *5* from opening its port too rapidly. The stem and spring also prevent the application valve from opening port *a* when a part of the pressure has been exhausted from the application cylinder during a partial release. During brake applications, the graduating stem strikes the cap nut *22* and compresses the graduating spring before the application valve opens.

20. Details of Application Portion.—In Fig. 8 (*a*) is shown the exhaust-valve seat, with the exhaust ports *d* and *e*

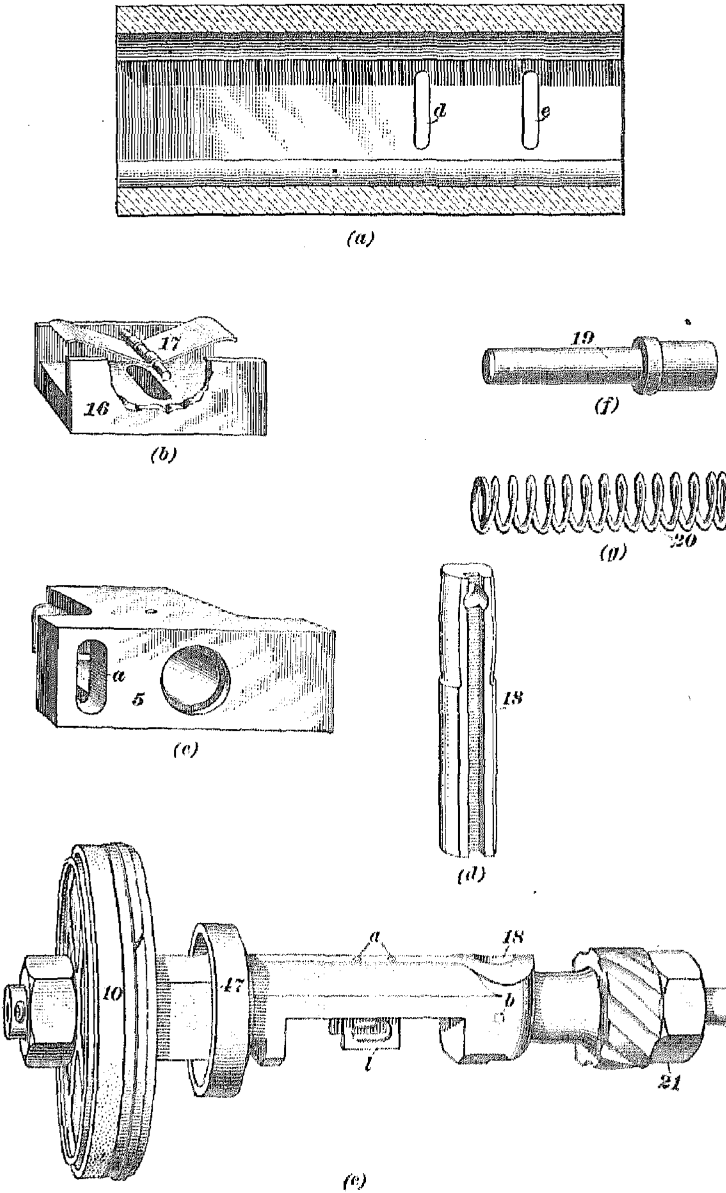


FIG. 8

that lead to the brake-cylinder exhaust port of the distributing valve; in (*b*) is a view of the exhaust valve *16* and spring *17*, the side of the valve being broken away to show the port that extends through the valve; in (*c*) is a view of the face of the application valve *5*, showing its port *a* and the opening into which the pin *18* fits; and in (*d*) is a view of the application-valve pin *18*, the upper end being rounded off in such a way as to permit a swivel action without unseating the application valve. This pin is made of steel and fits snugly in the opening *18* in the application-piston stem. It extends upward into the large round opening in the face of the application valve *5*, and its function is to transmit the motion of the application piston *10* to the application valve *5*. It is grooved to receive the pin *b* (view *e*) in the application piston and a similar pin in the opening in the application valve *5*, so that the application valve cannot be put in wrong end to and thereby prevent the passage of air through the valve. In (*e*) is shown a view of the application piston *10*, showing the rivets *a* that secure the exhaust-valve yoke *l* to the stem and the pin *b* that fits in the groove in the application-valve pin *18*. The rear end of the piston has spiral grooves, the purpose of which is to collect dirt and thereby permit the piston to move with less resistance. In (*f*) is shown the application-graduating stem *19*; in (*g*) is shown the spring *20*, and in (*e*), the application-graduating-stem nut *21*.

21. **Purpose of Equalizing Portion.**—The purpose of the equalizing portion of the distributing valve, Fig. 7, is to bring about the operation of the application portion when the brake is being operated by the automatic brake valve only, at which time the equalizing portion controls the flow of compressed air from the pressure chamber to the application chamber and cylinder when the brake is being applied, and its exhaust therefrom when the brake is being released.

22. **Description of Equalizing Portion.**—The equalizing portion of the distributing valve, Fig. 7, consists of the equalizing piston *26*, the equalizing slide valve *31*, and the graduating valve *28*. The equalizing piston operates within a brass bush *50*. The slide valve also operates within a brass bush.

The graduating valve is placed between two shoulders on the piston and therefore moves with every movement of the piston. The graduating valve operates on top of the equalizing slide valve. The slide valve is also placed between two shoulders *a* on the stem of the equalizing piston, and as the valve is shorter than the distance between these shoulders, the piston and the graduating valve can move a short distance either way without moving the slide valve. The graduating sleeve *44* and spring *46* prevent the piston *26* from moving past service position during service applications on short trains.

23. Purpose of Parts.—The purpose of the equalizing piston *26*, Fig. 7, is to move the equalizing slide valve *31* and the graduating valve *28* as well as to open and close the feed groove *v*. The outer face of the piston is exposed to brake-pipe air and the inner face is connected through a port and passage *o*, Fig. 10, to the pressure chamber. The equalizing slide valve opens communication between the pressure chamber, the application chamber, the application cylinder, and the safety valve when the brake is being applied, and between the application chamber, the application cylinder, the safety valve, and the distributing valve release pipe when the brake is being released.

The graduating valve *28* opens and closes a port in the equalizing slide valve *31* and thus graduates the flow of air from the pressure chamber to the application chamber and cylinder during service brake applications. The graduating valve also serves to make and break the connection between the application chamber and the safety valve in some of the positions of the distributing valve.

24. Details of Equalizing Portion.—In Fig. 9, view (*a*) is shown the equalizing piston *26*, the equalizing slide-valve spring *32*, and the graduating-valve spring *29*, and view (*b*) shows the graduating valve *28*, which contains a cavity *t*. Views (*c*) and (*d*) are top and bottom views of the equalizing slide valve, and view (*e*) shows the slide-valve seat.

When assembled, the graduating valve fits snugly between shoulders *b* on the stem, and the equalizing slide valve fits loosely between shoulders *a* on the stem. The graduating-valve

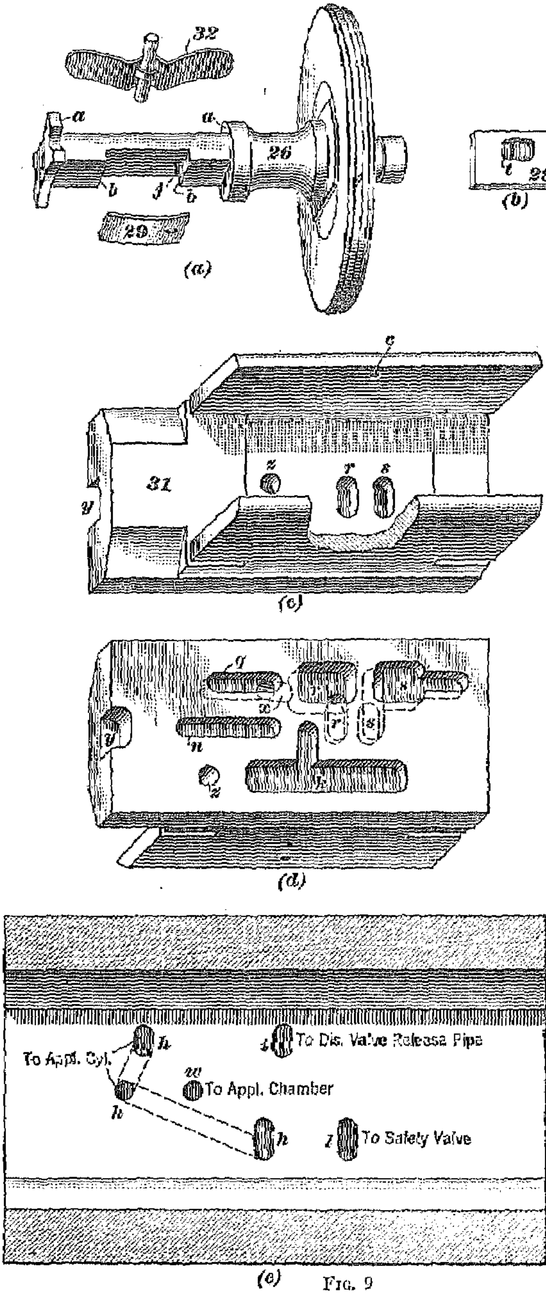

32
a
a
26
b
f
b
29
(a)
t
28
(b)
c
31
y
z
r
s
(c)
q
x
r
s
n
y
z
h
(d)
To Appl. Cyl.
h
h
h
w
To Appl. Chamber
To Dis. Valve Release Pipe
To Safety Valve
(e)

FIG. 9

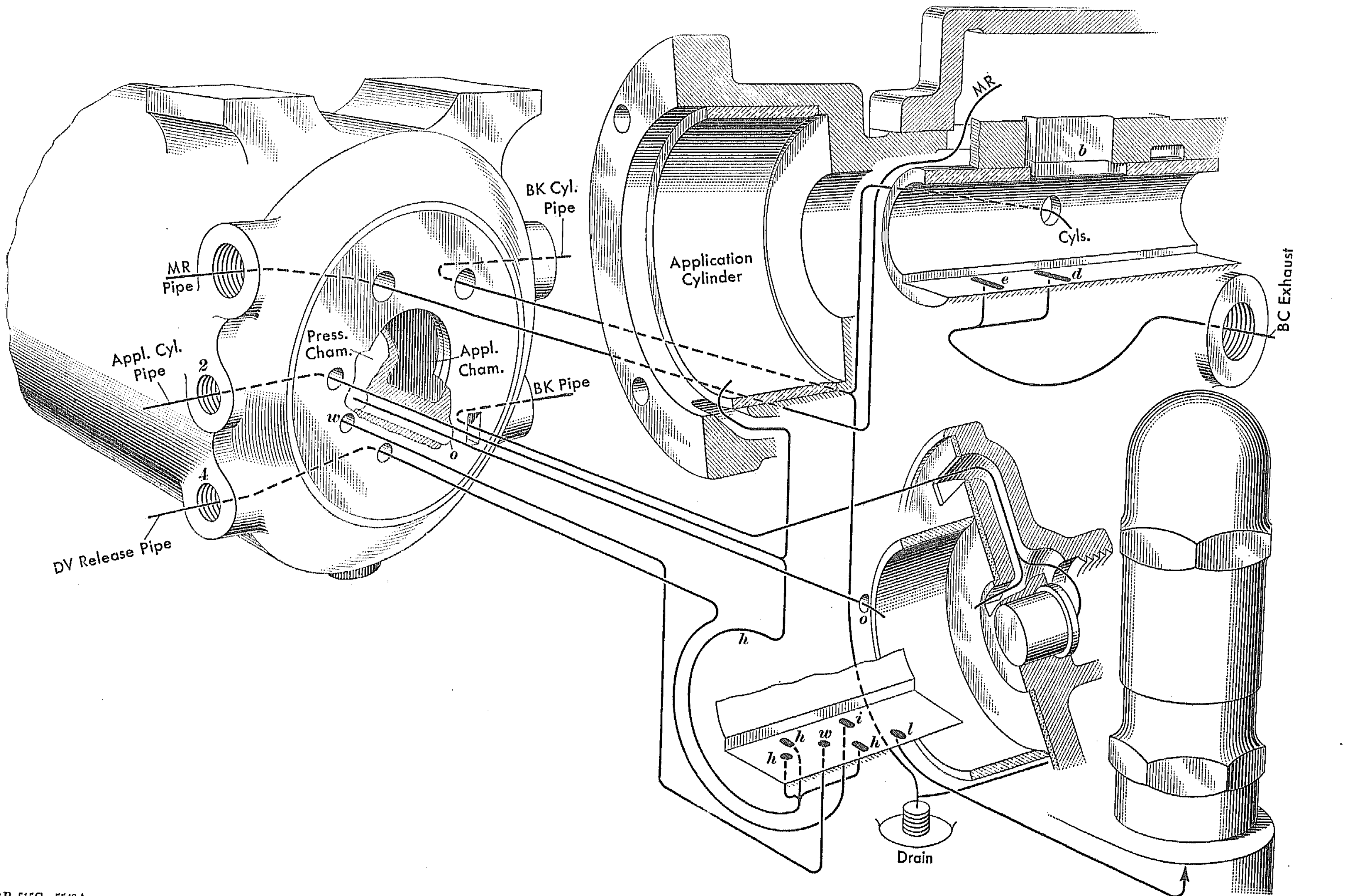

MR
Pipe
BK Cyl.
Pipe
Appl. Cyl.
Pipe
2
Press.
Cham.
Appl.
Cham.
BK Pipe
w
o
4
DV Release Pipe
Application
Cylinder
MR
b
Cyls.
e
d
BC Exhaust
o
h
h
h
w
i
h
l
Drain

Fig. 10

spring *29* is placed between the stem and the top of the valve, pin *j* extending through the hole in the spring and also into a hole in the graduating valve. Pin *j* also serves to prevent the graduating valve from being placed on the piston stem the wrong way. Spring *29* presses the graduating valve firmly against the top of the equalizing slide valve. The equalizing slide-valve spring *32* is held between the two sides of the equalizing slide valve by a pin that passes through the two small holes *c*, view (*c*). The spring prevents the valve from unseating and allowing dirt to get under it.

Ports *z*, *r*, and *s*, view (*c*), are connected by interior passages to ports *z*, *r*, and *s* in the face of the valve, view (*d*), but the ports in the top as shown in view (*c*) do not come directly over the ports in the face as shown in view (*d*). The face of the valve, view (*d*), contains two cavities *k* and *n*, and also a groove *q* which is connected to port *r* by passage *x*; *y* is a small shallow groove in the face of the valve. A passage, shown under the valve seat by dotted lines, view (*e*), connects the three ports *h* together.

25. Arrangement of Ports and Passages in Distributing Valve.—The arrangement of the ports and passages in the distributing valve is shown in Fig. 10, in which the passages are indicated by heavy black lines. In order to make the arrangement clear, the distributing valve is shown detached from the reservoir with all movable parts removed. The distributing valve is also broken away to show its interior, and the parts of the valve and reservoir not affected by the port arrangement are not shown.

The passage from the pipe connection *MR* leads through the double-chamber reservoir and the distributing valve, and terminates in port *MR* in the application valve chamber.

The passage extending from the pipe connection *2* leads through the double-chamber reservoir and the distributing valve, and connects to passage *h*. The upper end of passage *h* terminates in the application cylinder, and its lower end branches and ends in three ports *h*, in the equalizing slide-valve seat.

The passage leading from pipe connection *4* terminates in port *i* in the equalizing slide-valve seat.

The passage from the pipe connection *BK Cyl. Pipe* terminates in a circular opening *Cyls.* in the wall of the exhaust valve bush, A branch from the same passage leads to the drain plug *Drain* and to the cylinder cap. The passage extending from the pipe connection *BK Pipe* leads through the reservoir and the distributing valve, and enters the equalizing-piston chamber through the cylinder cap as shown.

Port *w* in the equalizing slide-valve seat is connected to the application chamber by a passage in the distributing valve and port *w* in the end of the double-chamber reservoir. Port *l* leads to the safety valve. Port *o* in the equalizing slide-valve chamber is connected by a passage extending through the distributing valve and a rib in the application chamber to the pressure chamber.

The brake-cylinder exhaust passage leads from ports *e* and *d* in the exhaust-valve seat to the *BC Exhaust.*

The distributing valve has two exhaust ports, the brake-cylinder exhaust port through which brake-cylinder air escapes when releasing the brake, and the distributing-valve exhaust port *i* through which the air from the application cylinder and chamber escapes when releasing the brake by either brake valve.

Under certain conditions the application-cylinder pipe also serves to exhaust air from the application cylinder and chamber.

H-6 AUTOMATIC BRAKE VALVE

26. Purpose.—The purpose of the H-6 brake valve will be evident from the following explanation of its six different positions:

Release and charging position provides a large and direct passage from the main reservoir to the brake pipe for the purpose of (*a*) charging the brake system, (*b*) quickly releasing and recharging the brakes, but (*c*) not for releasing the locomotive brake if it is applied.

Running position is the proper position for the brake-valve handle when the brakes are charged and ready for use. The purpose of the running position is automatically to maintain

the pressure in the brake pipe at a predetermined amount, and also to release the locomotive brake.

Holding position is used to hold the locomotive brake applied, and at the same time to recharge the brake-pipe, auxiliary reservoirs, equalizing reservoir, and pressure chamber, to brake-pipe pressure.

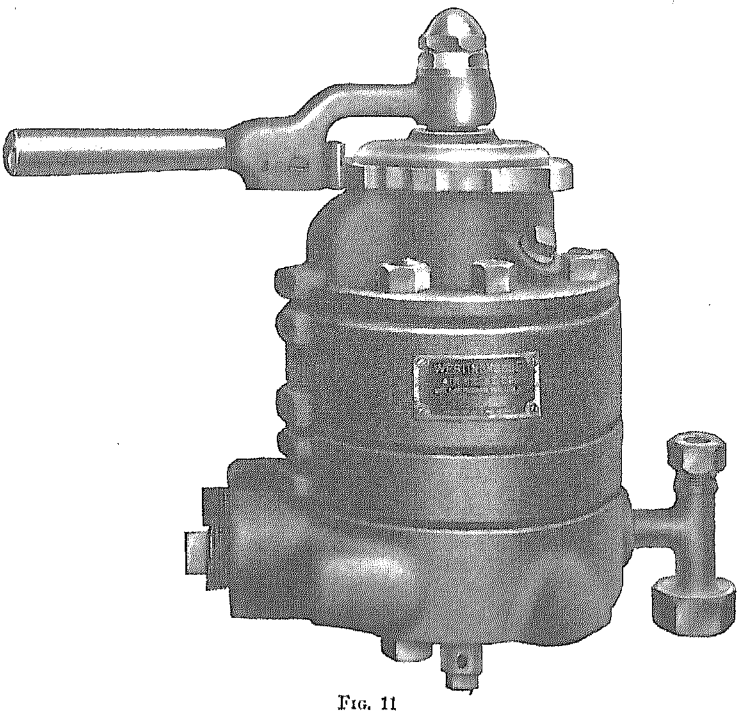


FIG. 11

Lap position is used to hold the brakes applied after a service application until it is desired either to make a further brake-pipe reduction or to release them. In freight service, lap position is also used to prevent the loss of main-reservoir air in the event of a burst hose, a break-in-two, etc.

Service position is used to open the service-exhaust port of the brake valve gradually, and automatically to close it in the same manner, thereby reducing the brake-pipe pressure in the proper manner for service braking.

Emergency position is used to make a quick and heavy application of the brakes, and also in passenger service to prevent loss of main-reservoir air and to insure that the locomotive brake remains applied in the event of a burst hose, a break-in-two, or the opening of a conductor's valve.

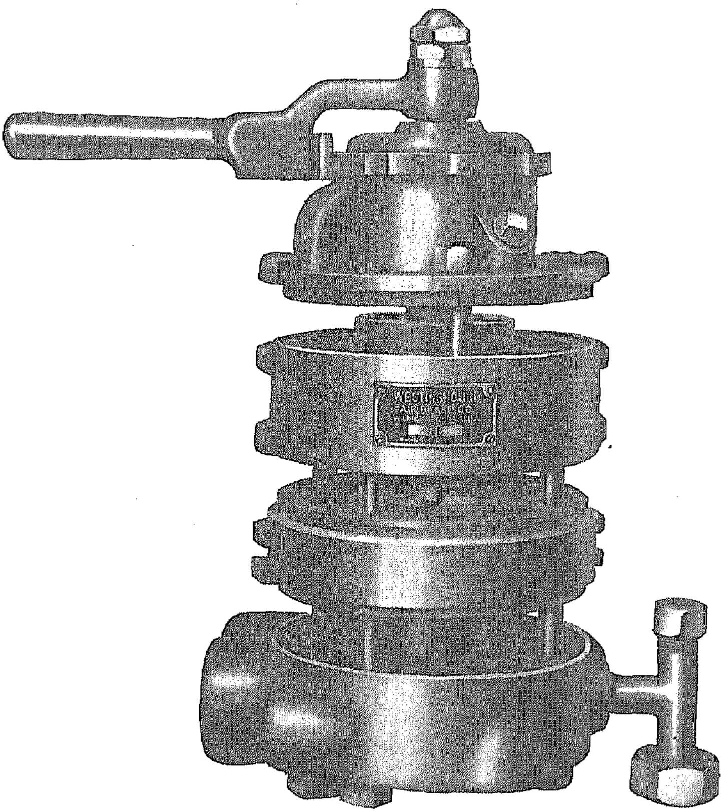


FIG. 12

27. Exterior Views.—An exterior view of the H-6 brake valve is shown in Fig. 11. Lugs between which a wedge may be inserted when it is desired to separate the parts are cast on the section of the valve as shown. In Fig. 12 the H-6 brake valve is shown separated into its four parts.

28. Names of Parts.—A section of the H-6 brake valve is given in Fig. 13. The names and numbers of the parts are as follows: *2,* bottom case; *3,* rotary-valve seat; *4,* top case; *5,* pipe bracket; *6,* rotary valve; *7,* rotary-valve key; *8,* key washer; *9,* handle; *11,* handle latch; *12,* handle-latch screw; *13,* handle nut; *14,* handle locknut; *15,* equalizing piston; *17,*

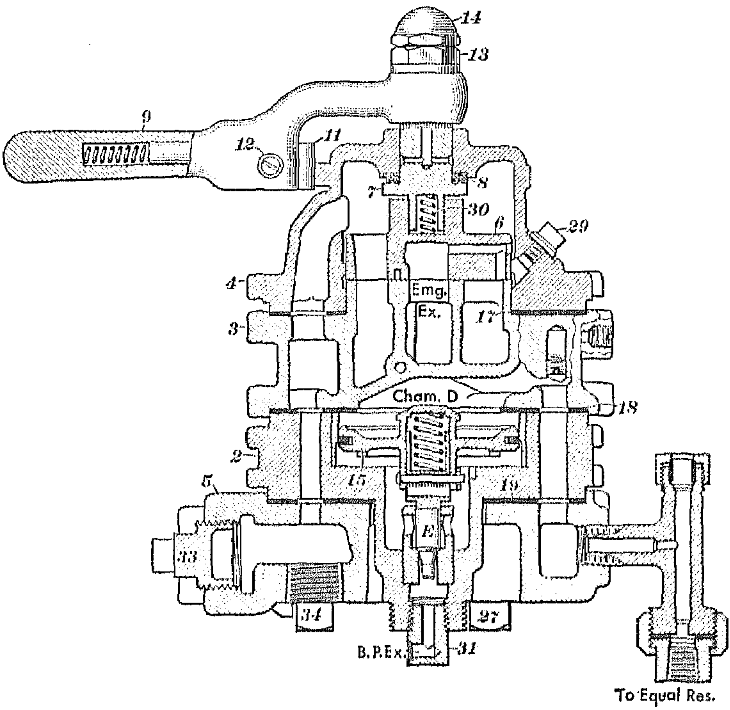


FIG. 13

upper gasket; *18,* middle gasket; *19,* lower gasket; *27,* bolt and nut; *30,* rotary-valve spring; *31,* service-exhaust fitting; *33* and *34,* pipe plugs; *25,* Fig. 14, bracket stud; and *26,* bracket stud nut used to secure the pipe bracket to the boiler stud; *28,* capscrews; *29,* oil plug.

29. Construction of Brake Valve.—The pipe bracket *5,* Fig. 13, contains all the pipe connections to the brake valve, and is provided with suitable ports and passages to convey the air

from the pipes to the respective ports in the brake valve. It is secured to the three upper sections of the brake valve by means of four bolts and nuts *27*, Fig. 14, which is a view looking down on the top case of the brake valve. The bolts pass entirely through the four parts of the valve and have the nuts on top.

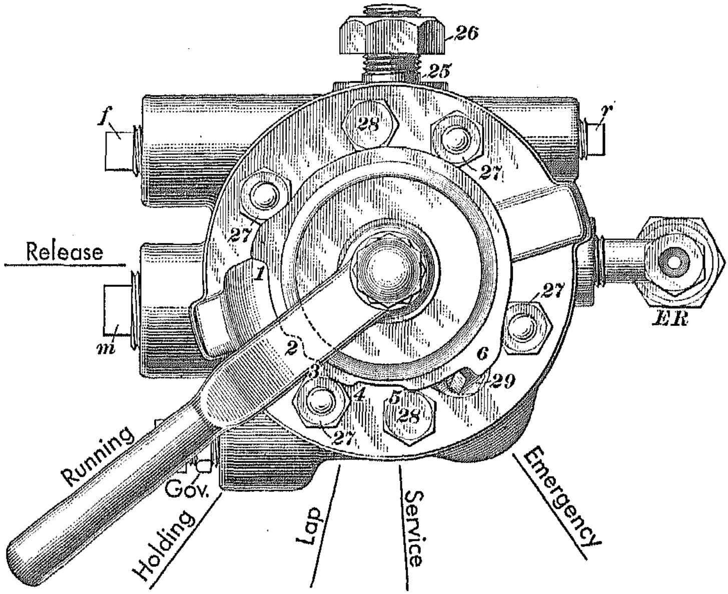


FIG. 14

The two capscrews *28*, secure the three upper sections *2, 3,* and *4,* Fig. 13, together. The brake valve, if desired, can be removed or changed by simply removing the four bolts and lifting the three upper sections off the pipe bracket, thus permitting repairs to be made without breaking pipe joints.

Suitable shoulders or stops numbered *1, 2, 3, 4, 5, 6,* Fig. 14, are cast on the projecting flange of the top case as shown, and the different positions of the brake valve are indicated when the latch in the brake-valve handle engages these stops. The brake valve has six positions, full release, running, holding, lap, service, and emergency.

The gaskets *17, 18,* and *19,* Fig. 13, prevent air from leaking between the ports or to the atmosphere. Gasket *18* is leather and gaskets *17* and *19* are rubber. The gaskets are applied with the smooth side down.

30. The equalizing piston *15* operates within the bottom case *2,* Fig. 13. The piston is normally balanced between equalizing-reservoir pressure on its upper face and brake-pipe pressure beneath it. The equalizing discharge valve *E* controls the passage of brake-pipe air through the service-exhaust fitting *31,* which is screwed into the center of the bottom case *2.* The emergency exhaust port *Ex* leads out to an opening in the side of the rotary-valve seat, directly over the bracket stud.

The rotary valve *6* operates within a ring cast on the interior of the top case *4* and is moved on the rotary-valve seat by the rotary-valve key *7* which obtains its movement from the rotary-valve handle *9.* The rotary-valve key is connected to the rotary valve by a wedge-shaped projection on the key, which fits into a slot in the rotary valve. The rotary-valve spring *30* holds the rotary-valve key *7* up against the key washer *8,* and also holds the rotary valve *6* on its seat during the time the brake valve is not charged with air pressure.

The leather key washer *8* prevents the escape of air past the key *7* where it passes through the top case. The oil passage shown in the rotary-valve key is used to apply oil to the key washer *8* when the handle locknut *14* is removed. The rotary valve can be lubricated by removing oil plug *29,* after the pressure in the brake valve has been exhausted.

31. Pipe Bracket.—A bottom view of the pipe bracket *5* turned completely over is shown in Fig. 15. The pipe bracket has eight pipes connected to it. The 1-inch main-reservoir pipe is connected at *MR,* the ¾-inch feed-valve pipe at *FV,* the low-pressure operating pipe at *Gov,* the 1-¼-inch brake pipe at *BP,* the equalizing reservoir pipe at *ER,* the ⅜-inch release pipe at *3,* the ⅜-inch application cylinder pipe at *2,* and the ¼-inch emergency relay valve pipe at the connection indicated. If desired, the main reservoir pipe, the feed-valve pipe and the release pipe may be connected to the side of the pipe bracket

instead of to the bottom by removing the plugs *m*, *f*, and *r*. The letters and figures indicating the pipe connections are cast on the pipe bracket. The lower portion of the bottom case, terminating in the service exhaust fitting *31*, extends downwards through the circular opening in the pipe bracket when the brake valve is assembled. The purpose of this fitting is to fix the maximum permissible opening from the brake pipe to the atmosphere when making a service application. The four lugs *a*, cast on the bracket prevent the bolts *27* from turning when applying their nuts.

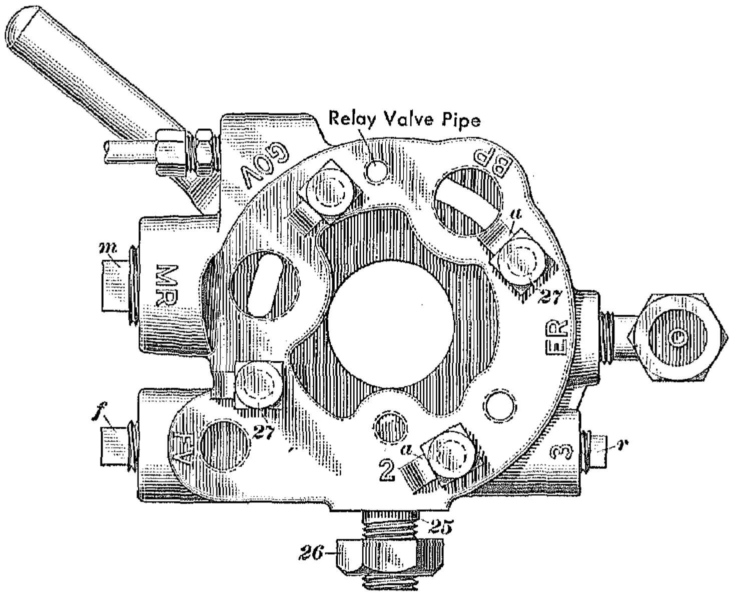


FIG. 15

The Type B pipe bracket shown in Fig. 15 is standard but the type C pipe bracket with the feed-valve directly attached may be substituted and the feed-valve pipe thereby eliminated.

32. Rotary Valve.—A top view of the rotary valve is shown in Fig. 16 (*a*). Ports *a*, *j*, and *s* extend entirely through the valve. The cavities in the face of the valve, with the valve turned completely over as in view (*b*), are *f*, *k*, *w*, *n*, *o*, and *x*. The connection between cavity *k* and cavity *n* is made by an

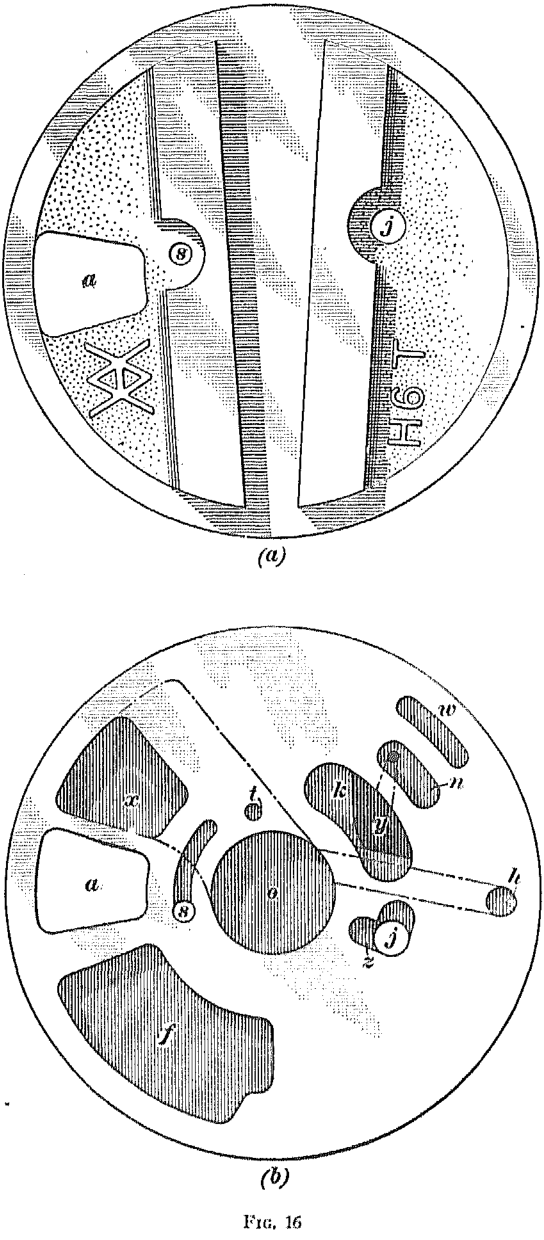


FIG. 16

interior passage *y* partly shown by dash lines and terminating in a small circular port in cavity *n*, known as the maintaining port. Port *h* is connected through an interior passage to cavity *o*. Cavity *x* is connected to cavity *o*, this cavity coming directly over the central emergency exhaust port in the rotary-valve seat. Port *t* is drilled into cavity *x* and port *s* through the valve connects to the groove shown. Port *j* terminates in two cavities in the face of the rotary, one being indicated by *z*.

In Fig. 17 is shown the port arrangement in the rotary valve

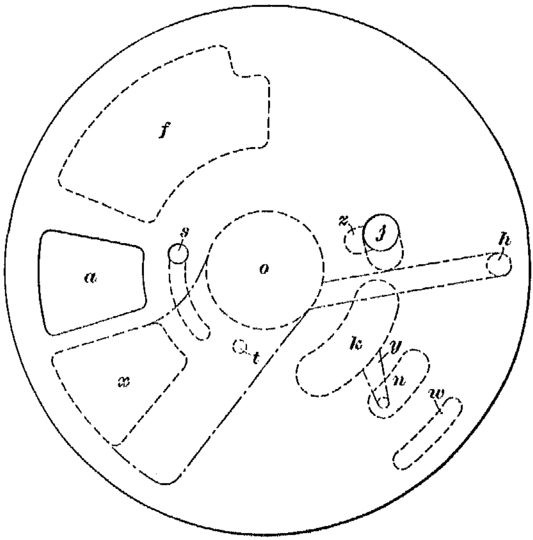


FIG. 17

as viewed from the top, with the valve assumed to be transparent. Full lines indicate ports through the rotary valve; short dash lines, ports or cavities in the face of the rotary valve; and long dash and dot lines, ports or cavities in the interior of the rotary valve.

33. Rotary-Valve Seat.—A view of the rotary-valve seat is given in Fig. 18, the pipe connections to the ports being plainly marked. The sanding port *y* was originally designed to admit air to the sanders during an emergency application but it is now used to convey air to the emergency relay valve instead.

34. Port Connections.—The connections made by the ports in the rotary valve with the ports in the rotary valve seat, Figs. 17 and 18, are as follows: Port *a* registers with the brake-pipe port *b* in full release position. Cavity *f* connects port *d* to port *b* in running and holding positions, and port *d* to the warning port *r* in full release position. Port *h* registers with port *l* in running position, port *l'* in holding position, and port *e* in service position. Port *j* registers with port *g* in full release position, with port *d* in lap, service, and emergency positions

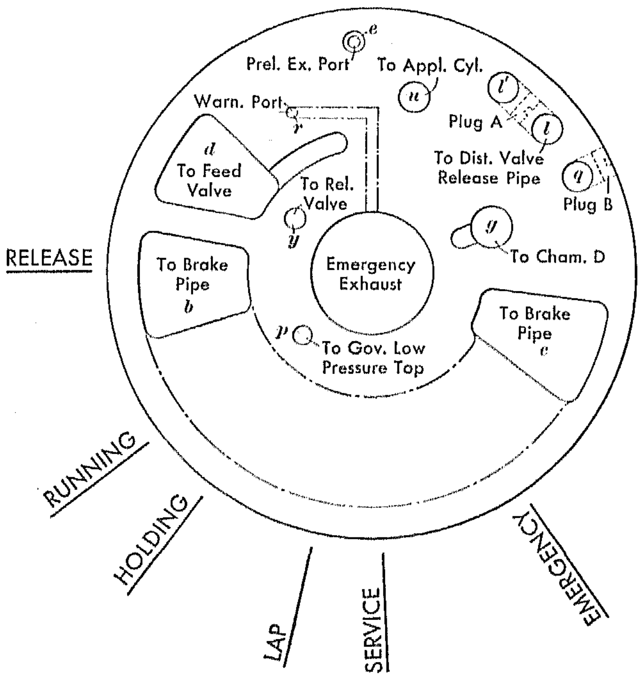


Fig. 18

and with the emergency relay valve port *y* in emergency position by way of cavity *z*. Cavity *k* connects port *c* to port *g* in running and holding positions, and port *d* to port *u*, by the way of passage *j* and cavity *n* in emergency position. Port *s* with its connecting cavity registers with port *p* in the first three positions of the brake valve. Port *t* registers with port *g* in

emergency. Cavity *w* connects ports *l* and *q* in lap position. Cavity *x* registers with port *c* in emergency position.

35. Eliminating Holding Position.—Holding position can be eliminated, if necessary, by removing a brass plug *A*, Fig. 18, from a passage in the under side of the rotary-valve seat. The removal of this plug, Fig. 22, connects the two passages in the rotary-valve seat that terminate in ports *l* and *l'*. Port *l'* in holding position is connected through passage *h* in the rotary valve to the emergency exhaust. Hence the air in the application cylinder and in the distributing valve release pipe vents by way of port *l'*. The reason for eliminating holding position is to prevent it from being confused with running position. Should the brake-valve handle be carried in holding position in error, the outlet for any leakage into the application cylinder of the distributing valve will be cut off and the locomotive brake will apply.

36. Releasing Brake in Lap Position After Release Position.—By removing a brass plug *B*, Fig. 18, in the side of the rotary-valve seat, the locomotive brake will release in lap position provided the brake valve has first been moved to release position. The removal of this plug permits the air in the distributing-valve release pipe and in port *l* to escape through cavity *w* in the rotary valve and port *q* to the atmosphere. The reason for releasing the locomotive brake following a movement of the brake valve from full release position to lap position is to enable passenger trains to be stopped more smoothly when a two-application stop is made.

37. The foregoing operation does not mean that the normal purpose of lap position, which is to hold the brakes applied after a service application, is affected; but it means that the locomotive brake will release at practically the same time as the train brakes, when the brake valve is placed on lap after being first placed in release position, as on the completion of the first application of a two-application stop with a passenger train.

The usual procedure in such a case is to move the brake valve to full-release position to release the train brakes, then

to running position to release the locomotive brake, and finally to lap position until it is desired to begin the second application. It sometimes happens that the brake valve is not left long enough in running position to release fully the locomotive brake before being moved to lap position, the result being that the locomotive brake will develop a higher braking force on the second application than is developed by the brakes on the cars, with consequent liability of shocks and sliding wheels, unless the release of the brake is completed, as with the new design of brake valve, when the brake valve is placed in lap position. Also, if the brake valve were left in running position long enough to release fully the locomotive brake, the brake-pipe pressure would be liable to be considerably higher on the front than on the rear of the train, which would also result in rough handling of the train on the second application.

The reason that the locomotive brake releases in lap position following release position, and not in lap position following service position, will be apparent when the operation of the distributing valve is taken up later, the reason being that the distributing-valve release pipe and the release pipe contain application-cylinder pressure in the first instance and not in the second.

38. Equalizing Piston.—The purpose of the equalizing piston is to bring about automatically a reduction in brake-pipe pressure equal to that made in the equalizing reservoir pressure by the operation of the brake valve. It follows from this that the time the brake-valve handle is held in service position to reduce the pressure in the equalizing reservoir will be independent of the length of the train.

The lower end of the stem of the equalizing piston is known as the equalizing discharge valve, the purpose of which is to stop gradually the discharge of brake-pipe air and so prevent the pressure at the head end of the brake pipe from being built up by the air flowing from the rear, which might cause some of the head brakes to release.

The equalizing piston is made collapsible so as to keep automatically the equalizing reservoir pressure at practically

the same pressure as the brake pipe during a release of the automatic brakes, so that a reapplication can be made more promptly than if the piston was in one piece.

39. In Fig. 19 (*a*) is shown a sectional view of a collapsible equalizing piston in normal position, the bottom case of the brake valve also being shown in section. View (*b*) shows a partial section of the equalizing discharge valve removed from the piston. The equalizing piston *15* and the equalizing discharge valve *E* are in two parts, the upper end of the discharge valve extending into and making a sliding fit in an opening in the stem of the piston, the two parts being held extended in

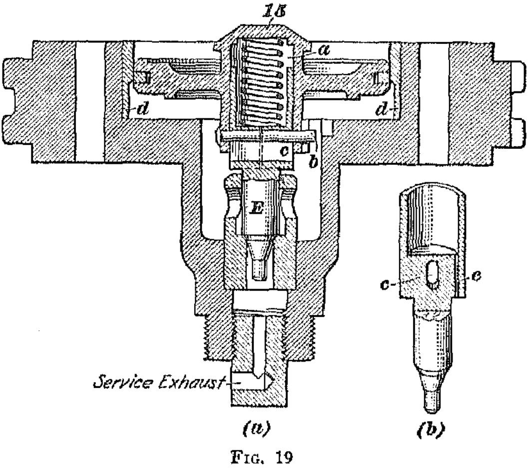


Fig. 19

normal position by spring *a*. The piston and the discharge valve are held together by a pin *b*. The pin fits tightly in the piston, but the opening *c* in the discharge valve through which the pin passes is slot-shaped as shown in view (*b*). Therefore the piston can be moved up and down without moving the discharge valve, as pin *b* has a vertical movement in slot *c*. Grooves *d*, of which there are four, serve to connect the upper and the lower faces of the piston when it is forced downwards. The small port *e* allows air to enter the spring chamber and thus approximately to balance the air pressure on each end of the discharge valve.

The strength of spring *a* is considerable; but, as the top of the piston has a greater area than the bottom, it only requires a pressure in the equalizing reservoir of about 2 pounds in excess of the pressure in the brake pipe to cause the piston to move downward, or to collapse.

40. Operation of Equalizing Piston.—The pressure in the equalizing reservoir becomes slightly higher than the pressure in the brake pipe, when releasing the brakes on a train of any length, owing to the small volume of the reservoir as compared with the volume of the brake pipe and the brake reservoirs on the cars. When this happens, the excess pressure on top of the equalizing piston compresses the spring and forces the piston down to a position in which the by-pass grooves in its bushing are uncovered, thereby permitting the pressure in the equalizing reservoir and the brake pipe to equalize. The piston will then lift promptly on a reapplication of the brakes. However, if for any reason the equalizing piston should fail to move upward to normal position after operation, there would be no discharge of air at the brake-pipe exhaust port when the brake valve is moved to service position. The reason is that the piston, when in its collapsed position, uncovers the four grooves in the bushing so that the air can pass into the chamber above the piston as fast as it is escaping through the preliminary exhaust port in the brake valve.

PEDESTAL BRAKE VALVE

41. Description.—The pedestal brake valve is one in which the H-6 automatic and the S-6 independent brake valves are mounted on a pedestal, this arrangement reducing leakage and the maintenance required in keeping the pipe joints tight. Also, the pedestal brake valve gives more room in the cab and improves its appearance. The pipe brackets of the automatic and independent brake valves are omitted when the brake valves are mounted on a pedestal.

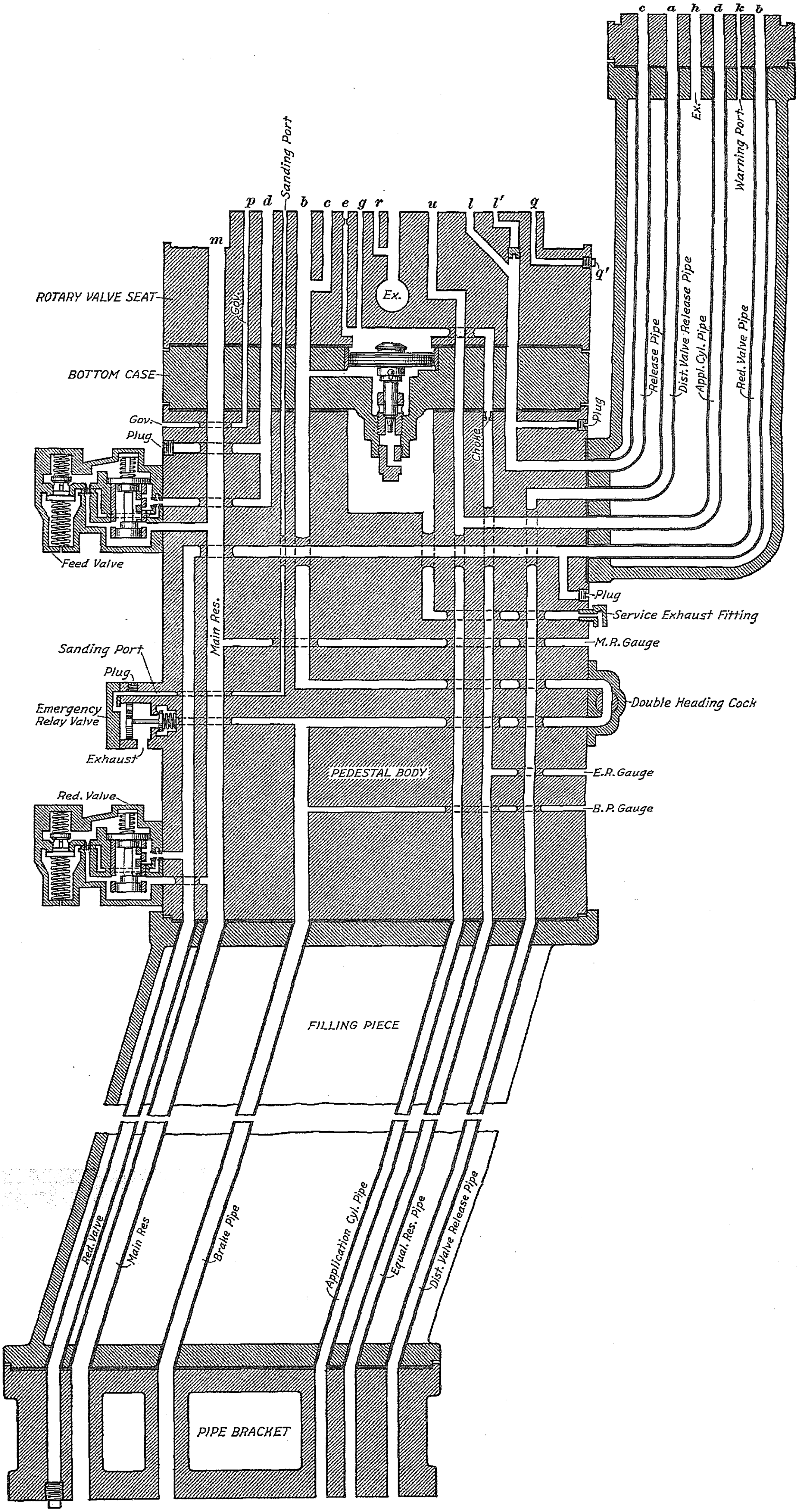
In Fig. 20 is shown an exterior view of a pedestal brake valve with an angle filling piece to conform to the slope of the boiler head. This type of brake valve consists essentially of

a pipe bracket, at the bottom a half-round hollow filling piece that contains the required piping and that has the side next to the boiler head open, and a pedestal body that incorporates the emergency relay valve, not visible, as it is on the opposite side of the body. On the pedestal body are mounted the H-6 automatic brake valve, which comprises the bottom case *2*, the rotary-valve seat *3*, the top case *4*, the feed valve, the reducing valve, the cut-out cock or double-heading cock, and the S-6 independent brake valve made up of the valve body *1*, and the rotary valve seat *3*. The bracket *38* serves to connect the independent brake valve to the pedestal body.

The pedestal body is anchored to the boiler by a holding stud, a tapped boss being cast on the boiler face of the pedestal body for that purpose. Four tapped lugs on the filling piece may be used to attach it to the boiler angle bracket or the pipe bracket may be bolted to a special casting installed on the boiler head. Pipe connections are made through the floor of the cab to the bottom of the pipe bracket, Fig. 21, and pipes in the filling piece and in the bracket *38* serve to make connection to the proper ports in the pedestal body.

42. Diagrammatic View.—In Fig. 22 is shown a diagrammatic view of the pipe bracket, the filling piece, the pedestal body, the bottom case, and the rotary-valve seat of the H-6 brake valve as well as the independent brake valve bracket, and the rotary-valve seat of this brake valve. The bottom case and the rotary-valve seat of the H-6 automatic brake valve, and the rotary-valve seat of the independent brake valve do not differ from the ordinary type and so require no description.

Provision is made for connecting the reducing valve exterior to the brake valve, should this arrangement become necessary, by removing the plug shown in the pipe bracket; the openings in the pedestal body for the reducing valve must then be blanked. Similarly, a feed-valve, exterior to the brake valve, may be piped to the feed-valve passage in the pedestal body that is shown plugged. The plug in the release-pipe passage in the pedestal body, when removed, causes the locomotive brake to release in holding and release positions as well as in lap posi-



BB 515C 5548A

FIG. 22

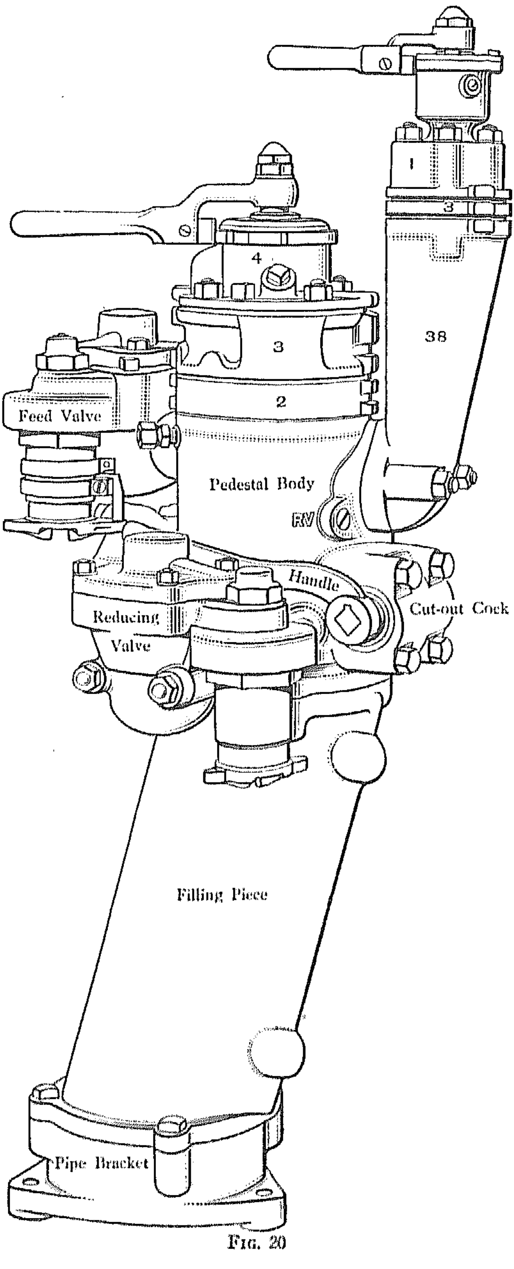

1
3
4
38
3
2
Feed Valve
Pedestal Body
RV
Handle
Cut-out Cock
Reducing
Valve
Filling Piece
Pipe Bracket

FIG. 20

tion following a movement to release position. Removing this plug gives the same effect as removing plugs q' and the plug in passage l'; also as already stated, the locomotive brake will in addition release in full release position. The service exhaust fitting is placed in the side of the pedestal body.

S-6 INDEPENDENT BRAKE VALVE

USE AND CONSTRUCTION

43. When Independent Brake Valve is Used.—The purpose of the independent brake valve is to operate the brakes on the engine and tender independently of the train brakes. The independent brake valve is most generally used to operate the

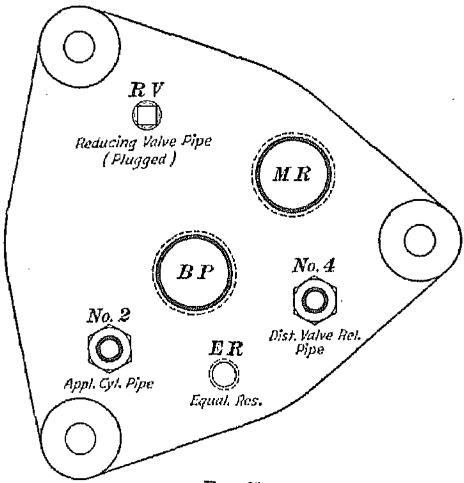


FIG. 21

locomotive brakes when no train is attached, and is therefore used when the locomotive is switching or taking coal or water; it is also used to prevent the possibility of an engine moving when standing under steam, or when work is being done about an engine. The independent brake valve can also be used in connection with the automatic brake to alternate the brakes on the locomotive and on the train in heavy-grade service and thus prevent the overheating of driving wheel tires, as well as to assist in holding the train at such times while the auxiliary reservoirs are being recharged.

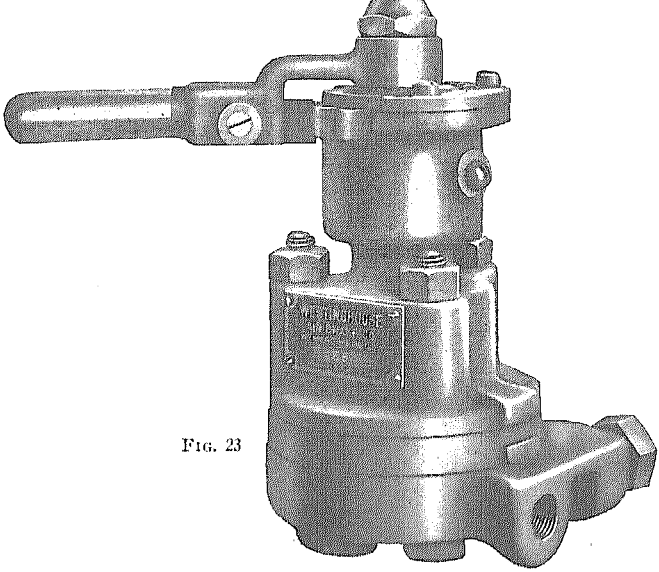


FIG. 23

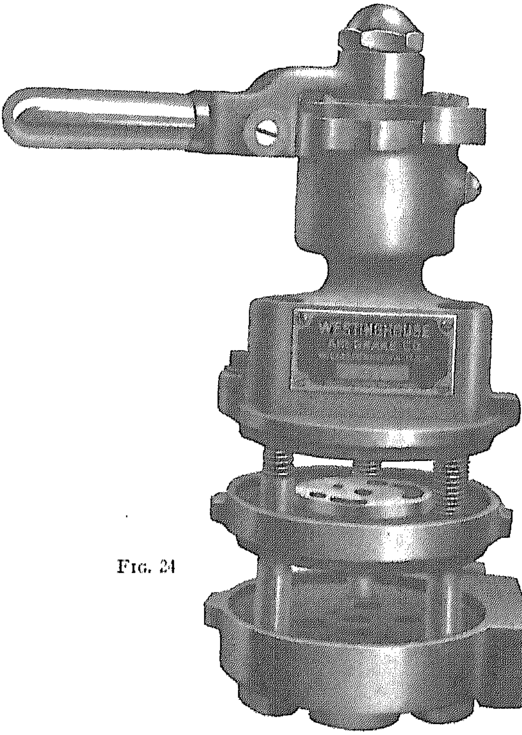


FIG. 24

44. Exterior Views.—In Fig. 23 is shown an exterior view of the S-6 independent brake valve, and Fig. 24 shows the brake valve separated into its three parts. As with the H-6

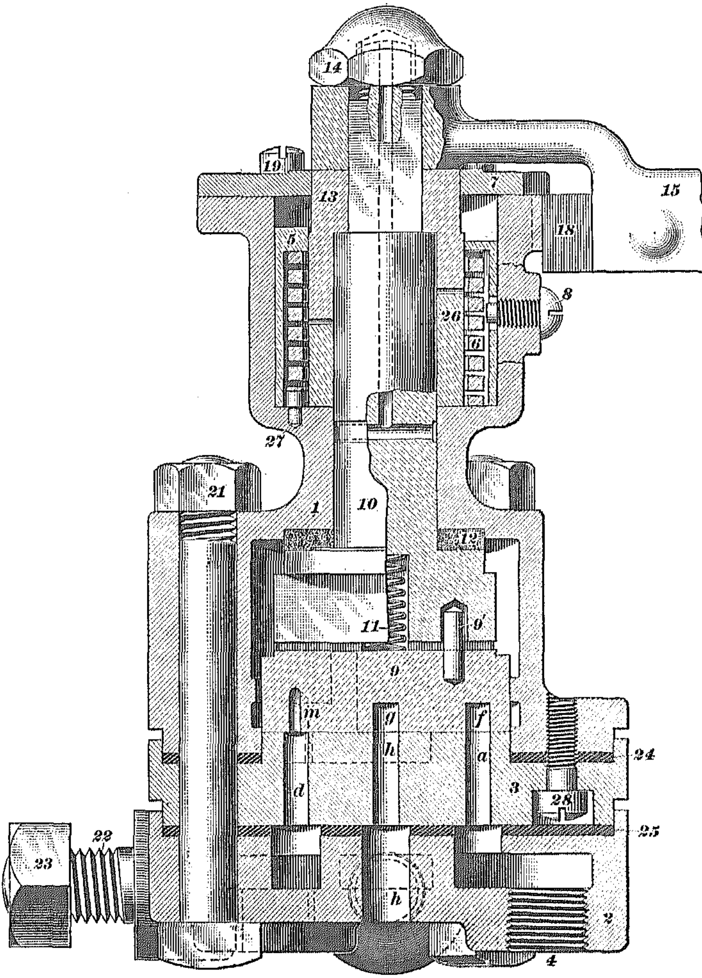


FIG. 25

brake valve, all pipe connections are made to the bottom part or pipe bracket, the two upper sections being secured to the pipe bracket by the three bolts shown. This arrangement

permits the brake valve to be repaired without disturbing the piping.

45. Names of Parts.—In Fig. 25 is shown the S-6 independent brake valve sectioned vertically, so as to bring out as many details as possible. The names and numbers of the parts of the S-6 independent brake valve are as follows: *1*, valve body; *2*, pipe bracket; *3*, rotary-valve seat; *5*, return-spring casing; *6*, return spring; *7*, cover; *8*, screw for return-spring casing; *9*, rotary valve; *10*, rotary-valve key; *11*, rotary-valve spring; *12*, key washer; *13*, upper clutch; *14*, handle nut; *15*, handle; *18*, latch; *19*, cover screw; *21*, bolt and nut; *22*, bracket stud; *23*, bracket-stud nut; *24*, upper gasket; *25*, lower gasket; *26*, lower clutch; *27*, return-spring stop; *28*, fillister-head screw.

46. Construction.—All pipe connections are made to the pipe bracket *2*, Fig. 25, and the two upper sections of the brake valve are secured to the pipe bracket by three bolts and nuts *21*, one of which is shown. The pipe bracket is secured to the boiler bracket by stud *22* and nut *23*. The two upper sections of the brake valve are secured together by two screws *28*, one of which is shown. Two rubber gaskets *24* and *25* prevent leakage between the ports or to the atmosphere. The arrangement that permits the rotary valve *9* to be moved by the brake-valve handle *15* is the same as with the automatic brake valve, the lower wedge-shaped part of the rotary-valve key fitting into a slot in the rotary valve. Pin *9'* prevents the rotary valve from being applied to the key the wrong way. The leather key washer *12* prevents air from leaking into the spring case. The washer can be oiled through the oil hole shown in the key, and the rotary valve can be oiled through an oil plug *20*, Fig. 26. The purpose and arrangement of the return-spring casing *5*, Fig. 25, the return spring *6*, the upper clutch *13*, and the lower clutch *26* will be explained further on. The cover *7* that forms the top of the return-spring chamber is secured to the valve body by three cover screws *19*, one of which is shown.

47. Top View of Brake Valve.—A top view of the independent brake valve is shown in Fig. 26. Suitable shoulders or

stops are cast on the valve body and the positions of the brake valve are indicated by the engagement of the latch in the handle with these stops. The brake valve has five positions, release, running, lap, slow-application and quick-application position.

48. Bottom View of Pipe Bracket.—A bottom view of the pipe bracket *2*, Fig. 25, is given in Fig. 27. The reducing-

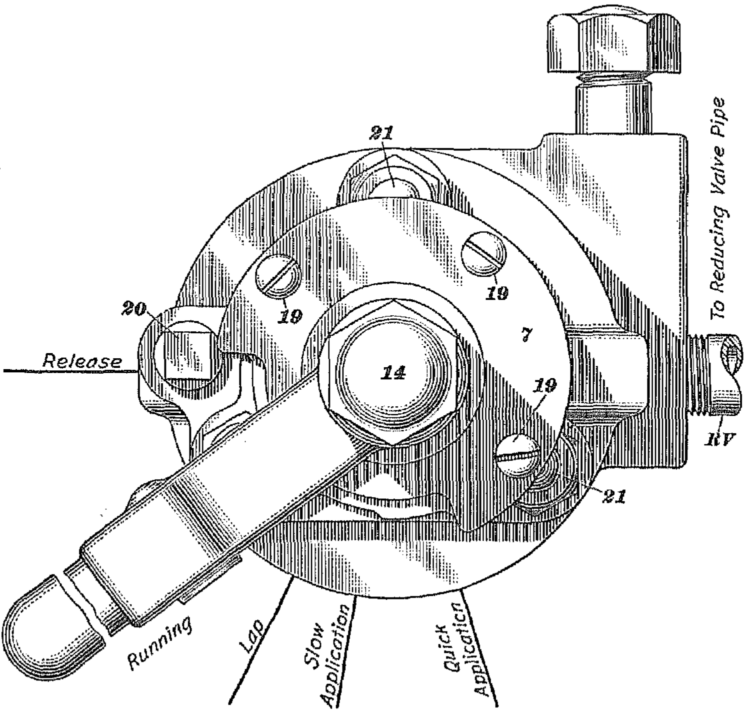


FIG. 26

valve pipe is connected to the pipe bracket at *RV*, the distributing-valve release pipe at *4*, the release pipe at *3*, and the application-cylinder pipe at *2*. The figures *2*, *3*, and *4* are cast on the bracket. The pipe connections having the same figures on the automatic and the independent brake valves are to be connected together; thus, *3* on the independent brake valve is to be connected to *3* on the automatic brake valve. The

figures on the distributing valve connect to similar figures on the independent brake valve; thus, *2* and *4* on the distributing valve connect to *2* and *4*, respectively, on the independent brake valve. *Ex* is the brake-valve exhaust port, and *k* is the warning port.

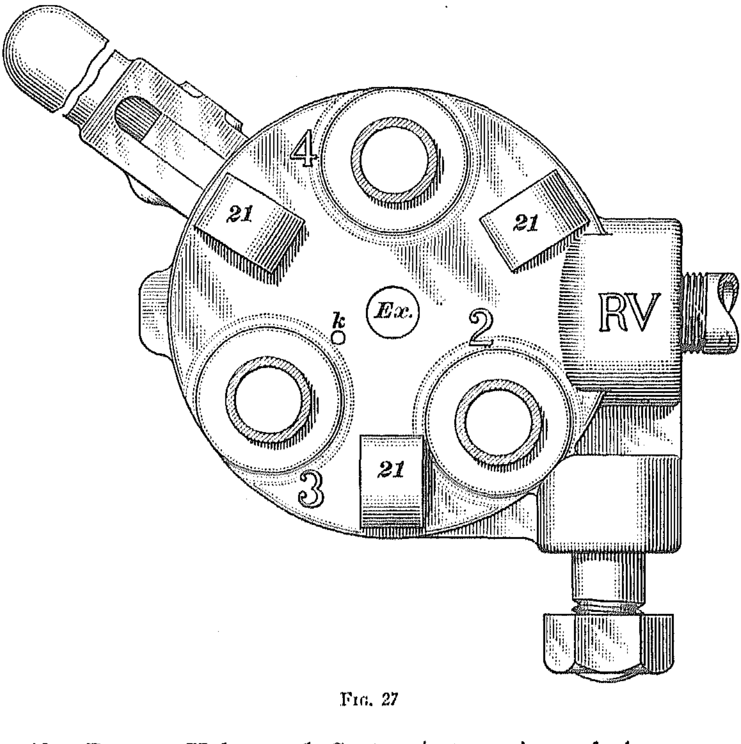


Fig. 27

49. Rotary Valve and Seat.—A top view of the rotary valve of the independent brake valve is shown in Fig. 28 (*a*). Ports *l* and *e* extend entirely through the valve. A transparent view of the valve is shown in view (*b*), *f* and *g* being cavities in the face of the valve. Port *m* is connected by an interior passage to port and groove *e*. A view of the rotary-valve seat is given in view (*c*).

50. Positions of S-6 Brake Valve.—The purposes of the different positions of the S-6 brake valve are as follows:

Release position is used to release the locomotive brake when the automatic brake valve is not in running position.

Running position is the position in which the independent brake valve should be carried when not in use. This position is used to release the locomotive brake when applied by the independent brake valve, at such times as the automatic brake valve is in running position.

Lap position is used to hold the locomotive brake applied after the desired brake-cylinder pressure has been obtained following an independent application.

Slow application position is used to apply the locomotive brake slowly.

Quick-application position is used to apply the locomotive brake quickly.

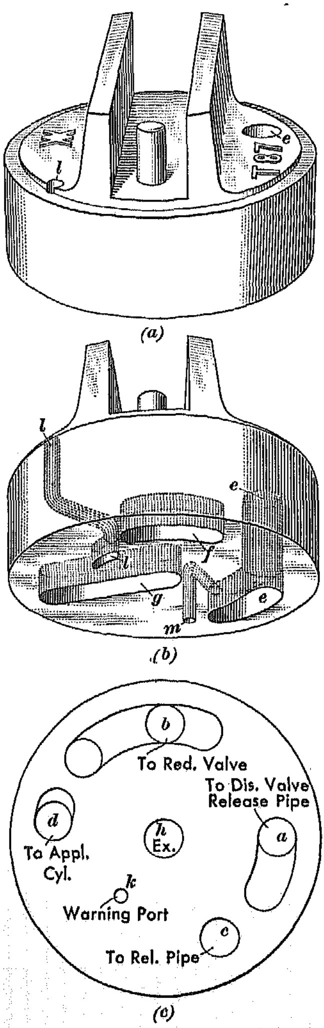


FIG. 28

RETURN-SPRING ARRANGEMENT

51. Purpose. — The purpose of the return-spring arrangement of the independent brake valve is automatically to move the handle of the brake valve from release position to running position, and from quick-application to slow-application position when the handle is released. It is necessary to return the brake-valve handle from release position, as otherwise the locomotive brake could not be applied by the automatic brake valve. The reason for the brake-valve handle resisting movement toward quick-

application position is to prevent the engineer from unintentionally moving the brake-valve handle to quick-application position and thus obtaining a heavy application of the locomotive brake, when only a light application is required, such as is obtained in slow-application position.

52. General Arrangement.—The return-spring arrangement is shown in position in the brake valve in Fig. 25 and disassembled in Fig. 29, similar parts being indicated by the same reference numbers in both illustrations. The parts, which comprise an upper clutch, a lower clutch, a return spring and a return-spring casing, are contained within the upper portion of the brake valve body.

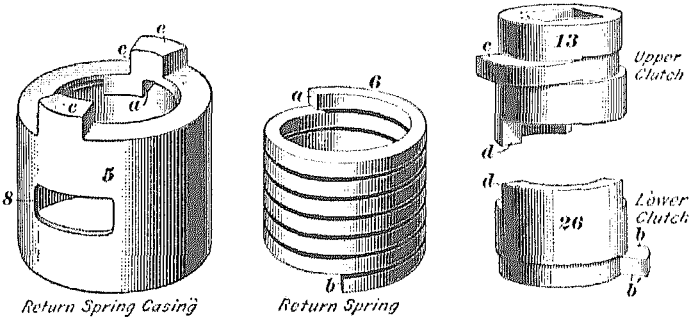


FIG. 29

The different parts of the apparatus that engage during operation are designated by the same reference letters. Thus, end *a* of the spring engages lug *a* on the casing, and end *b* of the spring engages the side *b* of the lug on the lower clutch, and side *b'* is normally in contact with pin *27*. The stop screw *8* normally engages the side *8* of the slot in casing *5* and *c* on the upper clutch engages at times the lug *c* on the casing *5*.

53. The lower clutch *26*, Fig. 25, is placed entirely on the rounded part of the rotary key *10*, and the upper clutch *13* is placed on both the rounded and the square parts of the key. The upper clutch therefore always moves with the key, while the movement imparted to the lower clutch is due to its engaging the upper clutch at certain times. The return spring *6* sur-

rounds the clutches and operates within the return-spring casing *5*. The lower portion of the upper clutch, Fig. 29, is cut away more than the upper face of the lower clutch, thereby permitting the upper clutch to turn some distance on the lower clutch before the parts *d* on each engage. The lugs *e* are of such a height that they hold the casing down the proper distance when the cover is in place.

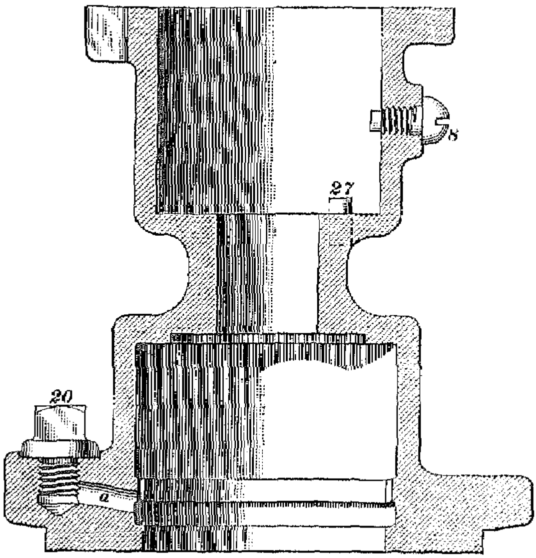


FIG. 30

54. Moving the brake valve handle to release position forces the lug *c*, Fig. 29, of the upper clutch against the side *c* of the lug *e* on the casing. This movement forces the lug *a* of the casing against the upper end of the return spring and tends to uncoil the spring and thereby place it under tension, because the end *b* of the spring is against the lug *b* of the lower clutch, the other side of the lug *b′* being against the stop *27*, Fig. 25. The brake-valve handle when released will then return to running position.

Moving the brake-valve handle from slow application position to quick application position forces the lug *d* of the upper clutch against lug *d* of the lower clutch. This movement places the

return spring under tension because the upper end of the spring is against the lug *a* of the casing, which now cannot turn as the casing screw is in the left end of its slot and holds the casing stationary. The arrangement of the return-spring parts is then such as to hold the lower end of the return spring stationary while pressure is being applied against the upper end, and to hold the upper end stationary while pressure is being applied against the lower end.

55. Removing Return-Spring Arrangement.—To remove the return-spring arrangement, first move the rotary-valve handle to release position, and while holding it there remove the casing screw *8*, Fig. 25. Move the handle back to running position, remove the handle nut *14*, take off the rotary-valve handle *15*, take out the three cover screws *19*, and remove the cover *7*. Place the thumb over one of the casing lugs *e* and hold the casing down while prying up the upper clutch *13* by inserting a pointed tool under the lug *c* that engages the lug of the casing *5*. This will disengage the upper clutch from the lower one, and release the tension of the return spring *6*, as will be indicated by a slight click. The upper clutch, casing, spring, and lower clutch can then be removed in the order stated.

56. Replacing Return-Spring Arrangement.—In order to replace the return-spring arrangement easily, the rotary-valve key should be in position in the valve body and the casing screw removed. Place the lower clutch *26*, Fig. 29, on the rotary key with the lug down, drop it into the return-spring casing, and turn it to the right until the side *b′* of the lug is against the return-spring stop *27*. Next drop the spring *6* over the key and lower clutch, and turn the spring to the right until the end *b* of the spring engages the side *b* of the lug on the lower clutch *26*. Next drop the casing *5* over the spring and turn the casing to the right until the end *a* of the spring comes in contact with lug *a* on the casing.

Turn the rotary-valve key until the position pin (located near the top of the key) points toward the casing-screw hole. Place the upper clutch *13* properly on the key with the flat end up, and press the clutch down as far as it will go. This brings

the lug *c* on the clutch near the side of lug *c* on the casing *5*. Next, place the brake-valve handle on the key and move it to release position. This will put tension on the spring and will bring the screw slot *8* in the casing opposite the casing screw. Press the casing down, if not already down, until its lugs *e* are flush with the top of the valve body, and then screw the casing screw all the way in so that it enters the slot in the casing. Let the brake valve return to running position and press the upper clutch down as far as it will go, if not already in position. Next, remove the handle *15*, secure the cover *7* in place, and replace the handle and secure it by means of the handle nut *14*.

STEAM COMPRESSOR GOVERNORS

57. Types of Governors.—The types of steam-compressor governors used with the No. 6 ET Equipment are the SD or duplex, the piping arrangement of which is shown in Fig. 31; the SF or excess-pressure type, shown in Fig. 32; and the AD or super-governor, illustrated in Fig. 33.

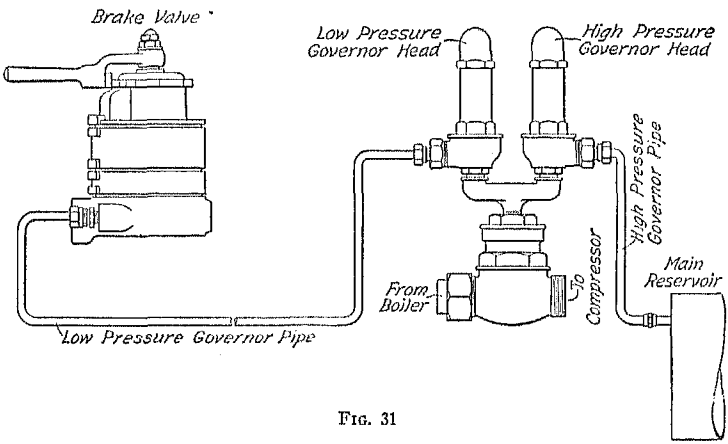


Fig. 31

58. Piping Arrangement of SD Governor.—With the SD governor, Fig. 31, the high-pressure head is connected to the first main reservoir and the low-pressure governor head is piped to a passage in the brake valve. With the handle of the automatic brake valve in either release, running, or holding

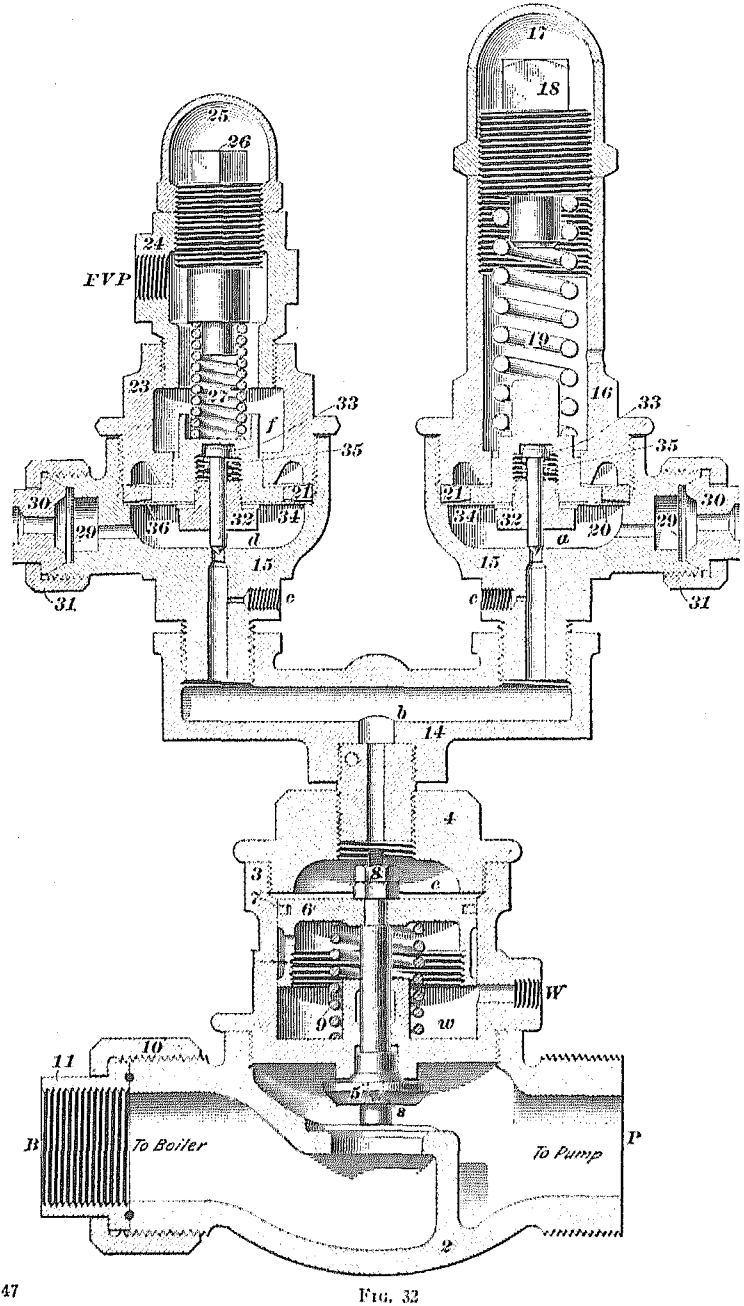


Fig. 32

positions, air from the main reservoir passes through the rotary valve to the low-pressure governor pipe. Therefore, in all these positions the ports register in such a way as to permit main-reservoir air to pass through the low-pressure governor pipe to the low-pressure governor head, which will operate and stop the compressor when the air pressure equals the adjustment of the regulating spring in this head.

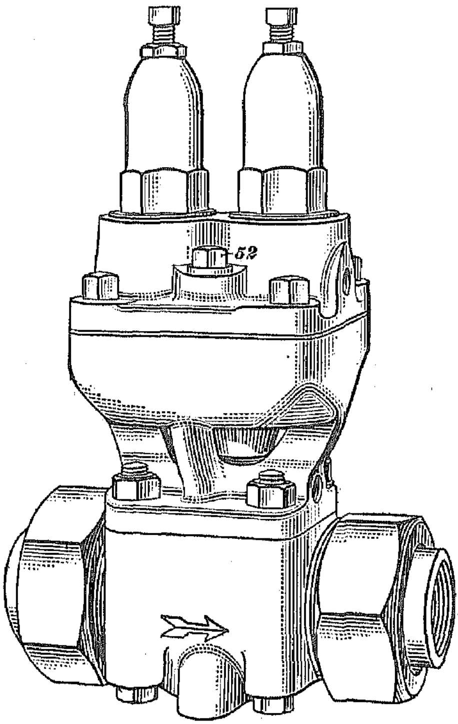


FIG. 33

In lap, service, and emergency positions, the air is prevented by the brake valve from passing to the low-pressure head of the governor. The compressor will continue to operate in the last-mentioned three positions of the brake valve until the pressure in the pipe connecting the high-pressure head to the main reservoir is about equal to the tension of the regulating spring in this head.

59. Piping Arrangement of SF Governor.—With the SF governor, Fig. 32, the maximum-pressure head is piped to the main reservoir, the excess-pressure pipe connects the top of the excess-pressure head to the feed-valve pipe, and the excess-pressure operating pipe connects the excess-pressure head to a passage in the brake valve. This type of governor is no longer in general use, its disadvantage being that any disorders in the feed-valve were reflected in the operation of the governor. In full release, running, and holding positions the ports in the brake valve are so arranged that main-reservoir air passes through ports in the valve to the excess-pressure operating pipe, and to the lower connection of the excess-pressure head, and causes it to stop the compressor when the main-reservoir pressure exceeds the pressure in the brake pipe by 20 pounds. In lap, service, and emergency positions, the ports in the brake valve are closed and the compressor operates until stopped by the maximum-pressure head, which receives air through the main-reservoir governor pipe.

60. Type AD Governor.—An exterior view of the AD super-governor is given in Fig. 33 and a sectional view is shown in Fig. 34. The development of this governor was necessary owing to the employment of superheated steam to operate the air compressor. The former types of governors were not designed to function with high-temperature steam. Modern practice entails temperatures as high as 750° F.

The steam-valve body *2* is of high-grade cast iron, and body erosion due to high-temperature steam is entirely missing, as the cast iron remains unaffected. The steam valve *5* is of stainless iron that is soft enough to provide a good seat and yet is heat-resistant; its bush *46* is of close-grained gray iron. The tubular stem of the steam valve is grooved externally to resist leakage of steam or oil along the stem with the valve between the upper and lower seats. Any leakage that does occur is vented to the atmosphere through the ports in the steam-valve bush and the vent shown.

The piston body *3* is bolted to the steam-valve body so that the main steam-line unions do not have to be loosened when mak-

ing repairs to the operating parts. The upper and lower portions of the piston body are connected by ribs; this arrangement insulates to a great extent the piston and the operating parts above

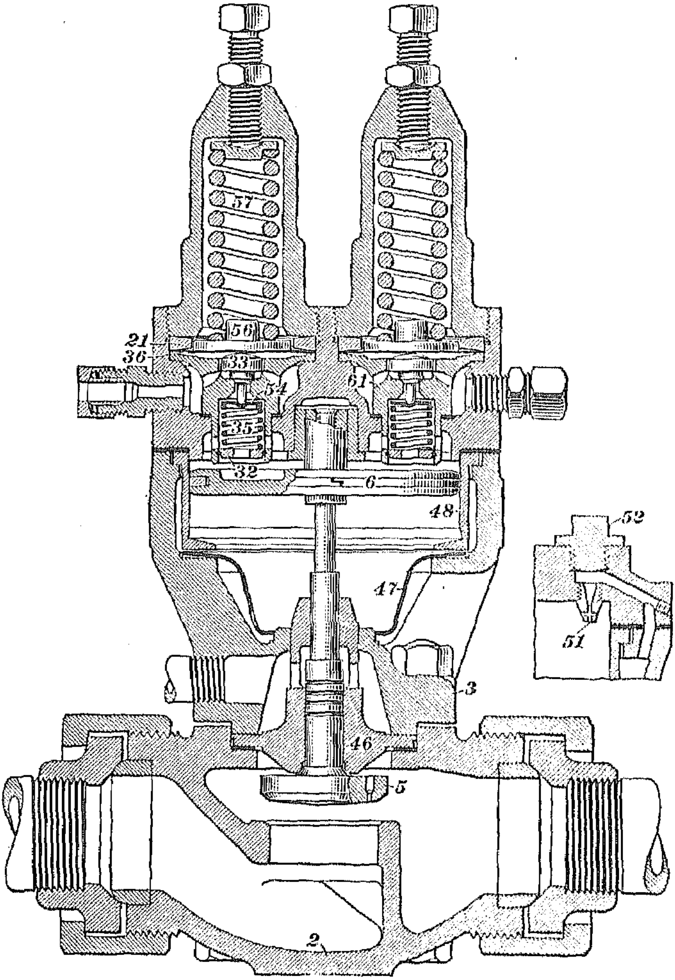


FIG. 34

it from the intense heat of the steam portion. A sheet-metal dust excluder *47* prevents dirt from entering between the ribs into the piston chamber. The stem of the piston *6* operates within the hole drilled to receive it in the steam valve.

In the regulating top the diaphragm ring is indicated by *21*, the diaphragm by *36*, and the regulating-spring seat by *56*. Each diaphragm valve *33* is normally held in contact with its seat *61* by the tension exerted by the regulating spring *57* on the regulating-spring seat. When the air pressure under one of the diaphragms overcomes the tension of the regulating spring, the diaphragm valve is moved upward and unseated by the diaphragm-valve spring *35*.

The spring rests on a spring seat *32* and the diaphragm-spring retainer *54* is interposed between the spring and the valve. The regulating top is secured to the piston body by four cap screws.

61. Operation of Type AD Governor.—When the main-reservoir pressure in the chamber below the diaphragm *36*, Fig. 34, plus the upward force exerted by the spring *35* against the diaphragm valve *33* becomes slightly greater than the downward pressure of spring *57*, the diaphragm and also the diaphragm valve will be raised, thus unseating the latter and allowing air to flow down above piston *6*. The steam valve then seats and shuts off the passage of steam to the compressor.

When the air pressure below the diaphragm falls below the tension of the regulating spring, the diaphragm valve seats. The air above the piston discharges through choke plug *51*, shown in the small view, the annular space surrounding the bushing *48*, the clearance space between the bushing and the dust excluder and through a vent port in the latter. The steam valve will then open. The venting of the air to the atmosphere by way of the annular space just mentioned has a cooling effect on the piston body. The choke plug cap nut *52* is provided to permit the $\frac{1}{8}$-inch opening in the choke to be cleaned out. The low-pressure top at the left controls the operation of the compressor in full release, running, and holding positions; the high-pressure top controls the compressor in lap, service, and emergency positions.

DEAD-ENGINE FIXTURES

62. Purpose.—The purpose of the dead-engine fixtures, when cut in, is to supply air from the brake pipe to the main reservoir of a dead engine or an engine with an inoperative compressor, so that the brake on this engine can be operated from the leading engine of the train.

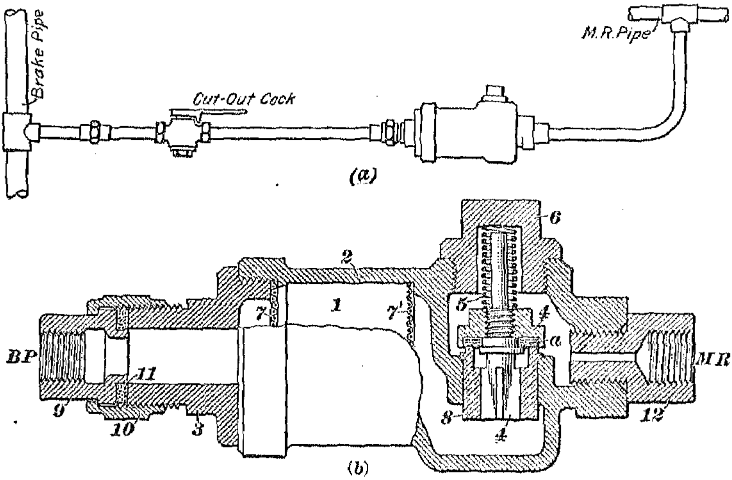


FIG. 35

63. Description.—An exterior view of the dead-engine fixtures and the pipes to which they connect is shown in Fig. 35 (*a*), and view (*b*) is a sectional view. The device consists of two short pieces of pipe, one of which is provided with a cut-out cock and connects a Type *C* strainer and check-valve to the brake-pipe. The other pipe connects the strainer and check-valve to the main-reservoir pipe. The dead engine fixtures are usually placed above the distributing valve, between the main reservoir and the brake pipe. This strainer and check is known as the Type *C-1-20-8*. The numbers and names of the parts are as follows: *1*, a brass cylinder that contains curled hair; *2*, valve body; *3*, cap nut; *4*, check-valve with leather face *a*; *5*, check-valve spring set for 20 pounds; *6*, valve cap; *7* and *7′*, strainers which form ends for cylinder *1*; *8*, check-

valve seat; *9,* union swivel; *10,* union nut; *11,* union gasket; *12,* choke plug with $\frac{1}{8}$-inch hole. The upper end of bush *8* serves as a seat for valve *4,* and the lower portion serves as a guide for the wings of the valve.

64. Operation.—When an engine with an inoperative air compressor is being operated in a train, or when a dead engine is being hauled in a train, the cut-out cock in the dead engine fixtures is opened, the double-heading cock is closed, and the handles of both brake valves are carried in running position.

Air from the brake pipe passes the cut-out cock and enters the combined strainer and check-valve at *BP,* Fig. 35 (*b*), passes through strainer *7,* the curled hair, and strainer *7′* to the chamber under the check-valve *4.* When the pressure is sufficient to overcome the tension of spring *5,* the check-valve unseats and the air passes through the choke plug *12* to the main reservoir. With a brake-pipe pressure of 70 pounds, a pressure of about 50 pounds will be provided in the main reservoir. The choke plug prevents a sudden drop in brake-pipe pressure, and therefore an application of the brakes, when uncharged main reservoirs are cut into a charged brake pipe. The check-valve prevents air from the main reservoir from passing to the brake pipe should the brake-pipe pressure on the dead engine be reduced below the pressure in the main reservoir. The cut-out cock should always be kept closed except when the dead-engine fixtures are in use, so as to prevent main-reservoir air from leaking into the brake pipe should the check-valve leak.

The reason for closing the double-heading cock is to break the connection between the main reservoir and the brake pipe through the rotary valve of the automatic brake valve, and from the brake pipe to the atmosphere through the service exhaust port when the brakes are releasing.

When the dead-engine fixtures are in use, the pressure chamber of the distributing valve charges from the brake pipe through the brake-pipe branch pipe. With the dead-engine fixtures cut in, the locomotive brake can be applied and released by the independent brake valve.

65. Type C-1-3-6 Strainer and Check-Valve.—The Type C-1-3-6 strainer and check-valve is placed between the reducing-valve pipe and the air-signal system, the arrangement permitting the use of one reducing valve for the independent brake valve and the signal system. It is unnecessary to illustrate this type of strainer and check-valve as it is exactly the same as the C-1-20-8 type with the exception that the choke plug has a $\frac{3}{32}$-inch opening and the spring has very little tension.

A leaky check-valve in this device will be indicated by the blowing of the signal whistle when the brake is applied by the independent brake valve. The reason is that the signal-pipe pressure is reduced by leaking past the valve.

NO. 4 PNEUMATIC BRAKE-PIPE VENT VALVE

66. Purpose of Valve.—The No. 4 pneumatic brake-pipe vent valve is a part of, and is regularly supplied with, No. 6 ET locomotive brake equipment. Its purpose is to discharge brake-pipe air to the atmosphere when the brake valve is placed in emergency position, thereby increasing the reduction made at the brake valve sufficiently to insure that quick action is started by the triple valves. An additional venting device is necessary on modern engines on account of the greater volume of the brake, and more bends and elbows in the piping, these conditions making it more difficult to propagate quick action. It can also be used on passenger and freight cars wherever a separate or additional brake-pipe venting device is required. The latest type of brake-pipe vent valve is provided with a strainer and a check-valve arrangement for by-passing the strainer should it become obstructed by dirt, and is known as the No. 4B.

67. Exterior and Diagrammatic Views.—In Fig. 36 is shown an exterior view of the No. 4 brake-pipe vent valve, and in Fig. 37 a diagrammatic view. The vent valve contains the following principal parts: Emergency piston *2*, with piston spring *11* and piston stop *12*; slide valve *3*; vent valve *4* with spring *4'*; quick-action piston *5* with spring *5'*; and ball check *6*. The pressure for actuating the device is contained in the quick-action chamber. The arrangement of piston *5* and valve *4* is similar to that of the emergency parts of a triple valve.

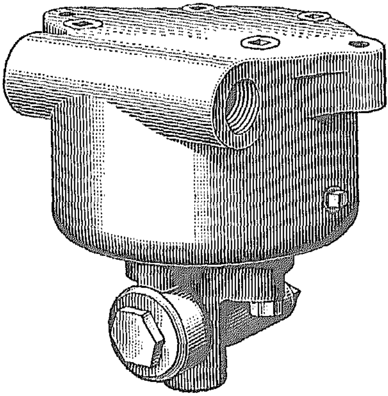


FIG. 36

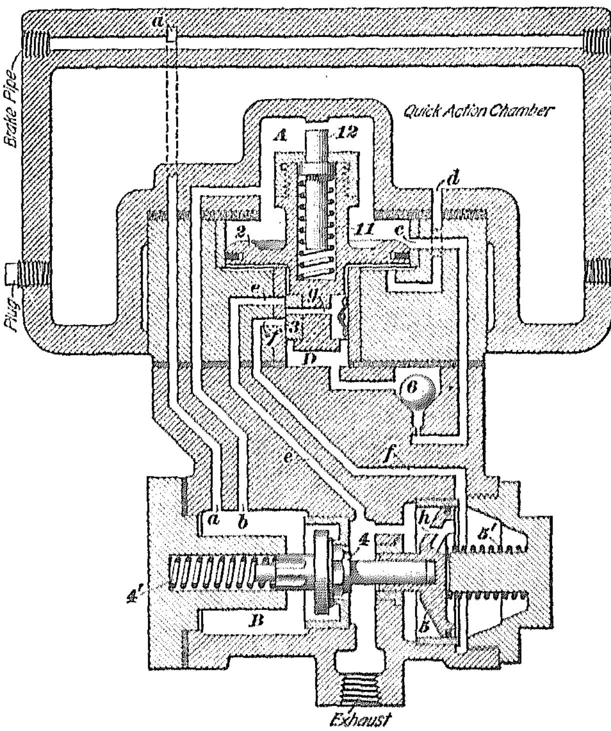

a
Brake Pipe
Brake Pipe
Quick Action Chamber
A
12
d
2
11
c
e
g
3
D
6
Plug
Plug
e
f
a
b
4
5'
4'
B
Exhaust

FIG. 37

68. Charging.—Air enters the vent valve from the brake pipe at either of the points shown in Fig. 37 and passes through passage *a* to chamber *B*, and then through passage *b* to chamber *A*. The quick-action chamber charges from cham-

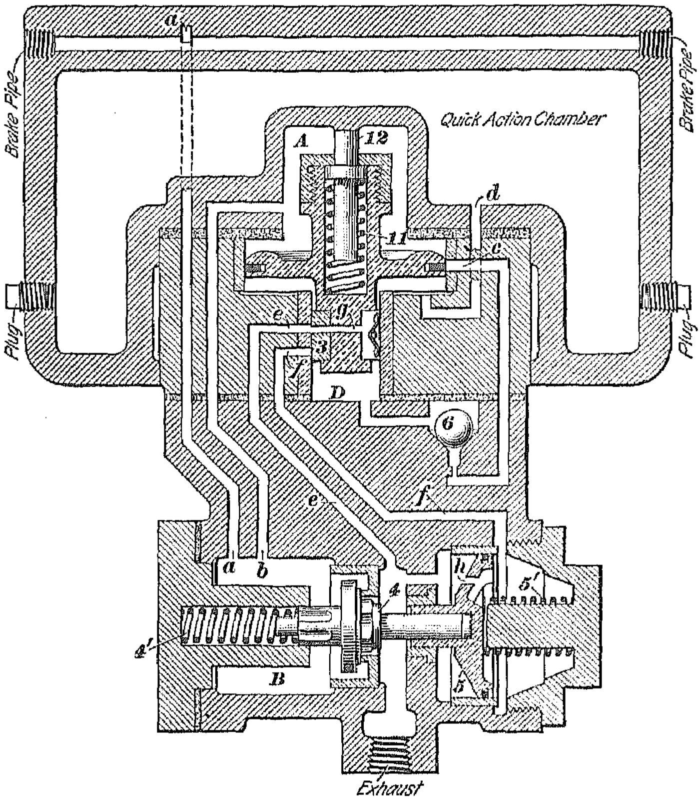


FIG. 38

ber *A* through passage *c*, ball check-valve *6*, chamber *D*, and passage *d*. When the charging is completed, chamber *A* and the quick-action chamber are charged to the same pressure as that in the brake pipe. The slide-valve seat is connected through passage *e* to the exhaust.

69. Service.—When the brakes are applied in service, the pressure reduces in chamber *A*, Fig. 38, and the now higher pres-

sure in chamber *D* moves the emergency piston *2* upward until its movement is arested by the compression of spring *11*, when the piston stop *12* strikes the reservoir above it, the first movement of the piston closing port *c*. In service position, port *g* in the slide valve *3* registers with port *e*, and the air in the quick-action chamber passes through passage *d*, port *g*, and passage *e* to the atmosphere at *Exhaust*. As the pressure in the quick-action chamber reduces at the same rate as the brake-pipe pressure, the vent valve does not operate and vent brake-pipe air at this time.

When the pressure in the quick-action chamber and chamber *D* reduces slightly below the pressure in the brake pipe and chamber *A*, the emergency piston will move the slide valve downwards and the valve will break the connection through ports *g* and *e*. When the brakes are released, the emergency piston is moved to release position, and the vent valve charges as already described.

70. Emergency.—The rapid fall in brake-pipe and chamber-*A* pressure following an emergency application, causes the much higher pressure in the quick-action chamber to move the emergency piston to the limit of its travel, and moves the slide valve *3*, Fig. 39, beyond port *f*. The air in chamber *D* and the quick-action chamber passes through port *f* to the outer face of quick-action piston *5*, which moves to the left and unseats vent valve *4*. The brake-pipe air in chamber *B* as well as in chamber *A* passes directly to the atmosphere through the exhaust port, thereby insuring a sufficient brake-pipe reduction to cause the nearest triple valve to go to emergency position. When the air in the quick-action chamber drains to the exhaust through port *h*, in piston *5*, the spring *4′* returns the parts to normal position.

71. Purpose of Ball Check-Valve.—The purpose of the ball check-valve *6*, Fig. 38, in combination with the arrangement of passages *d* and *c* is to prevent air from passing from the quick-action chamber and chamber *D* to chamber *A*, while the piston is closing port *c*. Any back flow of air at that time would be undesirable, as the volume of the quick-action chamber is

small, and back leakage from it to chamber *A* might prevent the formation of sufficient difference of pressure to move the piston. It is for this reason that a feed groove is not used to charge the quick-action chamber. Therefore, the arrangement of the ball check-valve and passages *d* and *c* permits air to pass from chamber *A* to chamber *D* and the quick-action chamber, but prevents it from returning.

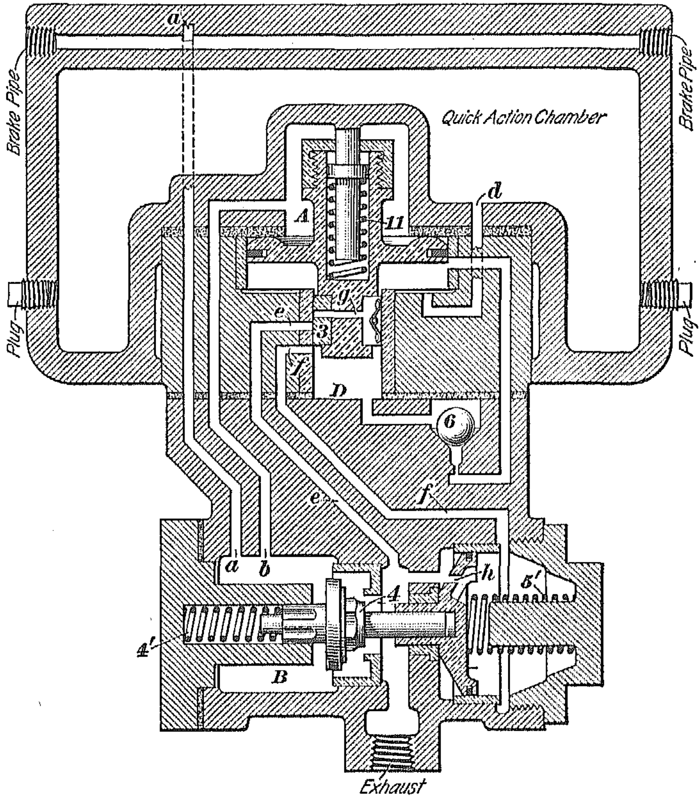


FIG. 39

72. Disorders.—An emergency application following the movement of the brake valve from release to running position when releasing brakes is caused by either port *g* or *c*, Fig. 39, being partly obstructed. In full release position, the quick-action chamber as well as the brake pipe on the front end of the

train charges higher at first than the rear end. When the brake valve is moved to running position, the brake-pipe air flows toward the rear of the train, and hence causes the pressure to lower on the front end. The emergency piston then moves out and as the air behind it cannot escape rapidly enough through the partly blocked ports, the piston is forced to emergency position.

A test to determine whether a vent valve will cause undesired emergency is to make a continuous service reduction of 20 pounds with the engine alone from maximum brake-pipe pressure. If the vent valve does not move to emergency position under these conditions, it will not cause undesired quick action when coupled to a train.

A continuous blow at the exhaust opening of the vent valve indicates a leak past the rubber seat of the quick-action valve *4*, or a leaky emergency slide valve. To determine which, remove the plug from the quick-action chamber, and if the blow at the exhaust continues it indicates quick-action valve seal leakage. If the blow stops, it indicates slide-valve leakage.

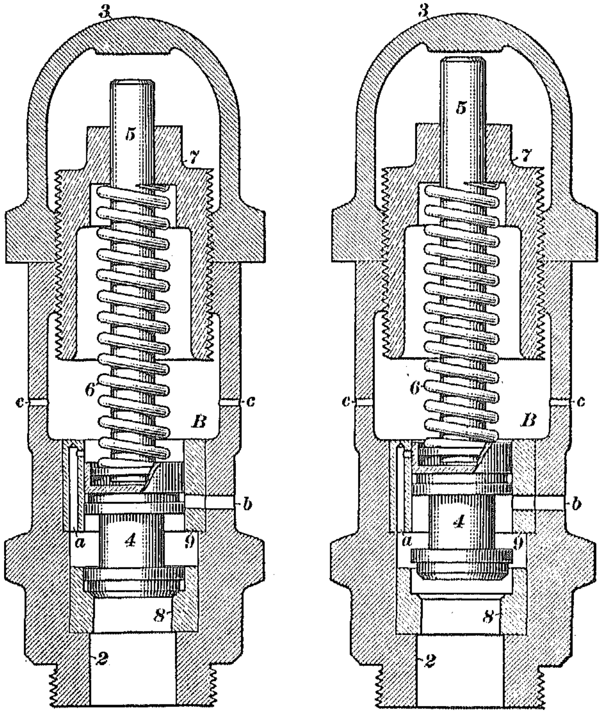
73. Installation.—The vent valve is installed in a vertical position on the tender in a branch pipe not over 6 feet long taken off the brake pipe and as near the rear bolster as possible, but not less than 20 feet nor more than 60 feet from the brake valve.

TYPE E-6 SAFETY VALVE

74. Description.—The E-6 safety valve is an essential part of the No. 6-E distributing valve, because it takes the place of the high-speed reducing valves and the safety valves used with the earlier types of locomotive brake equipment. The safety valve is connected to the application cylinder at all times except in automatic service lap position of the distributing valve. It is adjusted to 68 pounds, and to 35 pounds when the locomotive is being transported over the road light.

Two views of the E-6 safety valve are shown in Fig. 40. View (*a*) shows the valve in its normal, or closed, position, and view (*b*) shows the valve in its open position. The numbers and names of the parts of the E-6 safety valve are as

follows: *2*, valve body; *3*, cap nut; *4*, valve; *5*, valve stem; *6*, spring; *7*, adjusting nut; *8*, valve seat; and *9*, valve bush. The bush *9* acts as a guide for valve *4*. Bush *8* acts as a guide for the lower end of valve *4* and also as a seat for the valve. There are two vertical ports *a* that lead upwards through bush *9* and out at the top of valve *4* into the spring chamber, and two ports *b* that lead through bush *9* and the valve



(a) (b)

Fig. 40

body *2* to the atmosphere, but only one of each of these ports is shown in the illustration. There are also two ports *c* that lead from chamber *B* through the valve body *2* to the atmosphere.

The E-6 safety valve is specially designed for use with the No. 6-E distributing valve, and is screwed into the opening that connects to port *l* in the equalizing-valve seat as shown in the chart.

75. Operation.—The E-6 safety valve operates as follows: Air from the application cylinder enters the safety valve and exerts an upward pressure on the under side of valve *4*, Fig. 40 (*b*). When the pressure underneath valve *4* slightly exceeds the tension of the adjusting spring, the valve is raised, and as it rises, a larger area is exposed to the air pressure, which then causes it to move upwards quickly until the stem strikes the cap nut *3*. During this movement, the upper ends of the two ports *a* in the valve bush *9* are closed by the valve *4* and the ports *b* are opened. This allows air to pass to the atmosphere, and as the pressure decreases, the adjusting spring moves the valve *4* down toward its seat. During this movement, the ports *b* are closed and the upper ends of the ports *a* in the valve bush are opened. This allows air to pass into chamber *B*, and to escape to the atmosphere through ports *c* in the valve body. The air can pass into chamber *B* through the ports *a* faster than the air can escape from this chamber to the atmosphere through ports *c*. This causes a pressure to accumulate above valve *4* and assists the spring *6* in closing the valve with a "pop" action. This safety should be set at 68 pounds when used with No. 6 distributing valve.

76. Testing Safety Valve.—The safety valve can be tested by placing the brake valve in emergency position. The pressure shown on the brake-cylinder gage when the safety valve opens should be 68 pounds. If the safety valve fails to open, remove the cap nut *3*, Fig. 40 (*b*), and slack off on the adjusting nut *7*. If it then fails to open, release the brake, remove the safety valve and examine the strainer which is placed in the distributing valve below the safety valve. A leak at valve *4* or its seat will be indicated by a blow at port *c* when the brake is applied with the independent brake valve.

The safety valve will permit the application-cylinder pressure to build up above 68 pounds if ports *c* are restricted by paint, or if valve *4* is worn loose in bush *9*. If ports *c* are enlarged or if valve *4* is gummed up and makes too close a fit, the safety valve will permit the application-cylinder pressure to fall considerably below 68 pounds before it closes.

M-3-A AND M-3 FEED-VALVES

77. Purpose.—The purpose of the M-3-A feed-valve is to reduce main-reservoir pressure to the pressure desired in the brake pipe and to maintain automatically that pressure practically constant while the brake-valve handle is in either running or holding positions.

The M-3 feed-valve, referred to as the M-3 reducing valve, reduces the main-reservoir pressure for use in independent brake operation and for the train signal system. Both valves

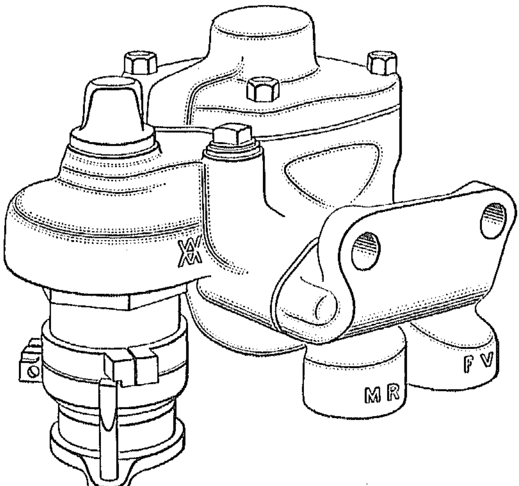


Fig. 41

are identical except that the M-3-A is provided with adjustable stops for double-pressure control. A rear view of the M-3-A feed-valve and its pipe bracket is given in Fig. 41, a diagrammatic view of the valve in open position is given in Fig. 42, and in closed position in Fig. 43.

78. Names of Parts.—The names of the principal parts of the M-3-A feed-valve, Fig. 42, are as follows: *2*, body; a venturi tube fitting comprising a bushing *3* and a nut *4*; *7*, regulating valve; *9*, regulating valve spring; *10*, regulating valve cap nut; *11*, diaphragm (two required); *12*, diaphragm ring; *15*, regulating spring; *16*, regulating spring box; *17*, regulating

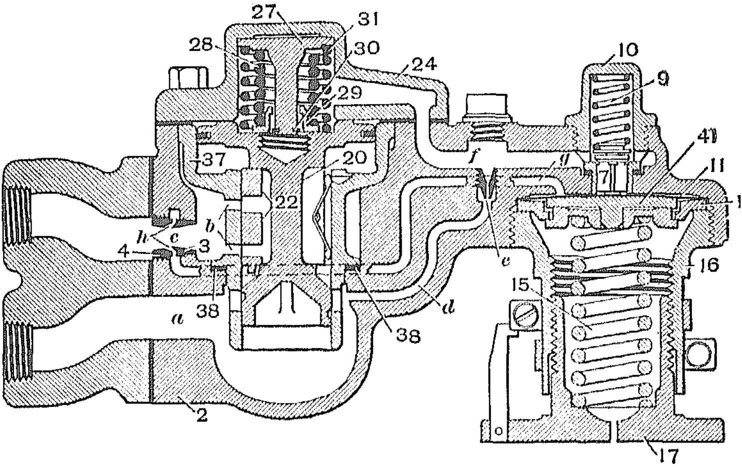

27
31
28
30
24
29
10
9
41
11
12
37
20
22
b
f
g
h
c
4
3
e
16
15
38
a
38
d
2
17

FIG. 42

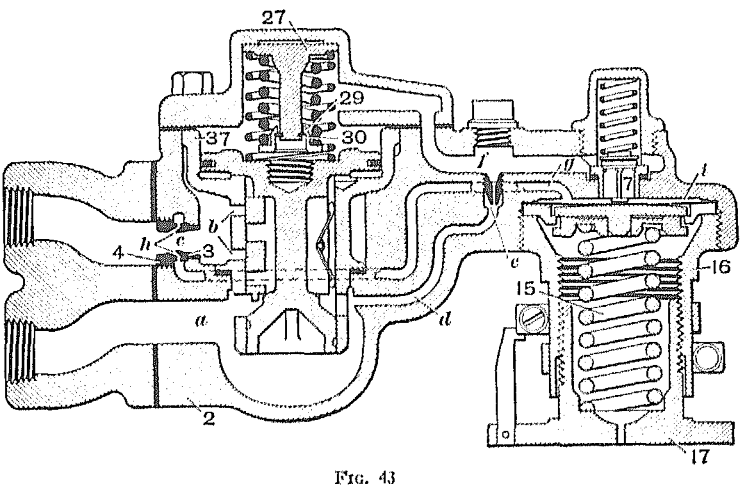

27
29
37
30
f
g
l
b
h
c
4
3
e
16
15
a
d
2
17

FIG. 43

nut; *20*, piston; *22*, slide valve; *27*, piston spring stem; *28*, inner piston spring; *29*, spring collar; *30*, spring collar retainer; *31*, outer piston spring; *37*, cage bush; and *41*, diaphragm follower; *e*, $\frac{1}{8}$-inch choke plug with $\frac{3}{64}$-inch drill.

79. **Open Position.**—With the feed-valve in open position, Fig. 42, the air from the main reservoir flows through passage *a*, the two ports in the slide valve and the two ports *b* in the seat, thence through the venturi tube to the feed-valve pipe and the brake pipe. The air in passage *a* also enters the passage *d*, passes through the choke *e*, and enters passage *f*, which leads to the outer face of the piston *20* and to the regulating valve *7*. The regulating valve is unseated by the spring *15* when the pressure in the brake pipe is less than standard, hence the air in passage *f* enters passage *g*. From this passage the air passes through the opening *h* between the venturi-tube bushing *3*, and the nut *4* to the feed-valve pipe. When the pressure in the feed-valve pipe, in passage *g*, and on the diaphragm *11* reaches the amount to which the regulating spring is set, the spring *15* is deflected and thereby permits the spring *9* to seat the regulating valve *7*. The air continues to flow through passage *d* into passage *f* until the difference between the pressures on either side of the piston *20* is about equal to the tension of the springs *28* and *31*. When this occurs, these springs force the piston and the slide valve *22* to closed position, as shown in Fig. 43.

80. When the pressure in the feed-valve pipe has been reduced a considerable amount below the adjustment of the regulating spring *15*, Fig. 42, the regulating valve *7* will be opened fully and the piston *20* will move upward to its extreme position. Both the ports *b* in the slide-valve seat will then be opened because the by-pass choke *f* so restricts the flow of main-reservoir air that the pressure cannot build up in the chamber above piston *20* as long as the valve *7* is fully unseated. Thus, the by-pass choke prevents any tendency for a premature closing of the feed-valve at this time. If the reduction in the feed-valve pipe pressure is limited, the regulating valve will not open fully; hence, the flow of air through the choke will be more effective

in building up the pressure on piston *20* and the result will be that the piston will only move up far enough for the slide-valve to open the upper port *b* in its seat.

81. Closed Position.—In closed position of the feed-valve, Fig. 43, air at main-reservoir pressure is present in passages *a*, *d*, and *f* and air at feed-valve pipe pressure is in passage *g* and *c*. A decrease in this latter pressure will permit the spring *15* to expand and thereby unseat the regulating valve *7*. The air in passage *f* immediately reduces to feed-valve pipe pressure, and the greater pressure in the main reservoir below the piston *20* will at once force it upwards. With the slide valve drawn to open position as in Fig. 42, the feed-valve pipe will again begin to charge as already explained.

82. Venturi Tube.—The purpose of the venturi tube is to prevent any tendency of the feed-valve to close at intervals before the pressure in the feed-valve pipe reaches standard pressure. It might be possible, without this tube, that the main-reservoir air might build up in passages *f* and *g*, Fig. 42, and compress the regulating spring *15*, thereby closing the regulating valve *7* before the pressure in the feed-valve pipe had reached standard pressure. This would cause an interruption in the flow of air to the brake pipe until the pressure in passage *g* has reduced below the setting of the regulating spring.

The manner in which the venturi tube obtains an uninterrupted or a sustained flow of air from the main reservoir to the feed-valve pipe is as follows: The venturi tube increases the velocity of the air while it is passing directly from the main reservoir to the feed-valve pipe. The bore of the tube widens gradually toward the outlet; the air, therefore, in its passage through the tube expands and lowers in pressure and increases in velocity. The action of the venturi tube on air is similar to the action of the steam nozzle of an injector on the passage of steam.

The air in the venturi tube, in passing at an increased velocity and a reduced pressure by the openings *h*, entrains and thereby induces a similar action on the air in the passage *g*. Therefore, any building up of air on the diaphragm *11* that would result in a premature closing of the feed-valve is prevented.

As the pressure in the feed-valve pipe nears standard, the velocity of the air through the venturi tube and passage *g* decreases; this permits pressure to accumulate in the diaphragm chamber *i*, Fig. 43, and close the regulating valve at its true setting.

The venturi tube obtains its name from the inventor, an Italian physicist of the eighteenth century.

EMERGENCY RELAY VALVE

83. Purpose.—The emergency relay valve, a sectional view of which is given in Fig. 44, is a venting device located on the engine in a branch from the brake pipe beyond the double-heading cock. It is controlled by the brake valve through a pipe that leads to the sanding pipe port in the brake-valve bracket.

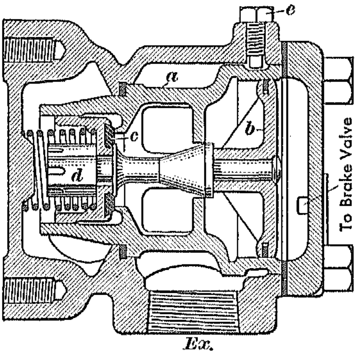


FIG. 44

The relay valve serves two purposes: It provides an additional opening in the brake pipe of a very large size, thus permitting brake-pipe pressure to drop at a very much faster rate than can be caused by the brake valve alone. Therefore, the relay valve provides additional capacity to the brake valve for insuring the transmission of quick action to the No. 4 brake-pipe vent valve and the train. The relay valve serves a second purpose by making it possible for the engineman to reduce the brake-pipe pressure at an emergency rate in the event that the double-heading cock is in closed position.

84. Description.—The emergency relay valve, Fig. 44, consists of a body with a slip bushing *a* of brass, held in place by a body cover and containing a piston *b* with a vent valve *c* attached to the opposite end of the piston stem by a castle nut *d*. The setscrew *e* facilitates the removal or replacement of the cover by holding the vent-valve cage in place when backing off

or tightening the cover-cap screws. The exhaust opening and the opening for the brake pipe are tapped for a $1\frac{1}{4}$-inch pipe. The connection for the pipe from the brake valve is tapped for a $\frac{1}{4}$-inch pipe.

85. Operation.—When the handle of the H-6 brake valve is moved to emergency position, main-reservoir air flows through the pipe to the sanding-pipe port to the face of the piston in the relay valve. The vent valve is then opened by the piston and permits air from the brake pipe to flow to the atmosphere and give the desired emergency reduction. The valve remains open as long as the brake-valve handle is in emergency position, but when moved out of this position the supply of main reservoir air is cut off. A small port in the piston then allows the air trapped in the vent valve to escape and a spring closes the valve.

CYLINDER CAP

86. Plain Cylinder Cap.—A sectional view of the plain cylinder cap is shown in Fig. 45 (*a*), and the face of the cap is shown in view (*b*). When the cap is bolted to the distributing valve, port *BP* registers with the brake-pipe passage in the valve. Brake-pipe air enters port *BP*, passes through an interior passage *BP*, view (*a*), also shown by dotted lines in view (*b*), and enters the chamber in front of the equalizing piston and to the graduating spring chamber through port *BP*. Port *xb* is put in the cap so that it can be used with the No. 14 EL distributing valve on electric locomotives.

AFTERCOOLER

87. Purpose of Aftercooler.—The compression of air is always accompanied by the accumulation of water in the reservoir in which the air is being stored. The purpose of the aftercooler is to cool the air in its passage from one main reservoir to the other, thereby hastening the precipitation of the entrained moisture, after which the moisture is drained off through automatic drain valves. These valves open each time the compressor governor operates to stop the compressor, as well as each time the governor starts the compressor.

88. Arrangement of Aftercooler.—The aftercooler and its piping arrangement are shown in Fig. 46. The device is installed in the piping between the first and the second main reservoir, with the automatic drain valves piped to the compressor governor. The aftercooler comprises two headers *a* between which are a series of horizontal $1\frac{1}{8}$-inch finned copper tubes *b* in each

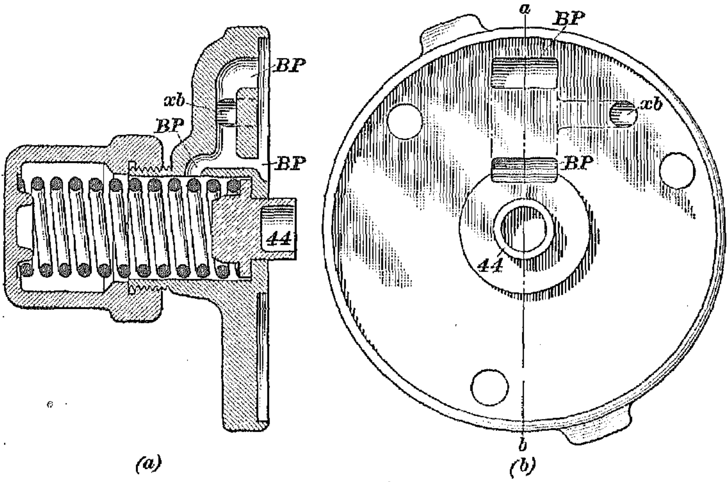
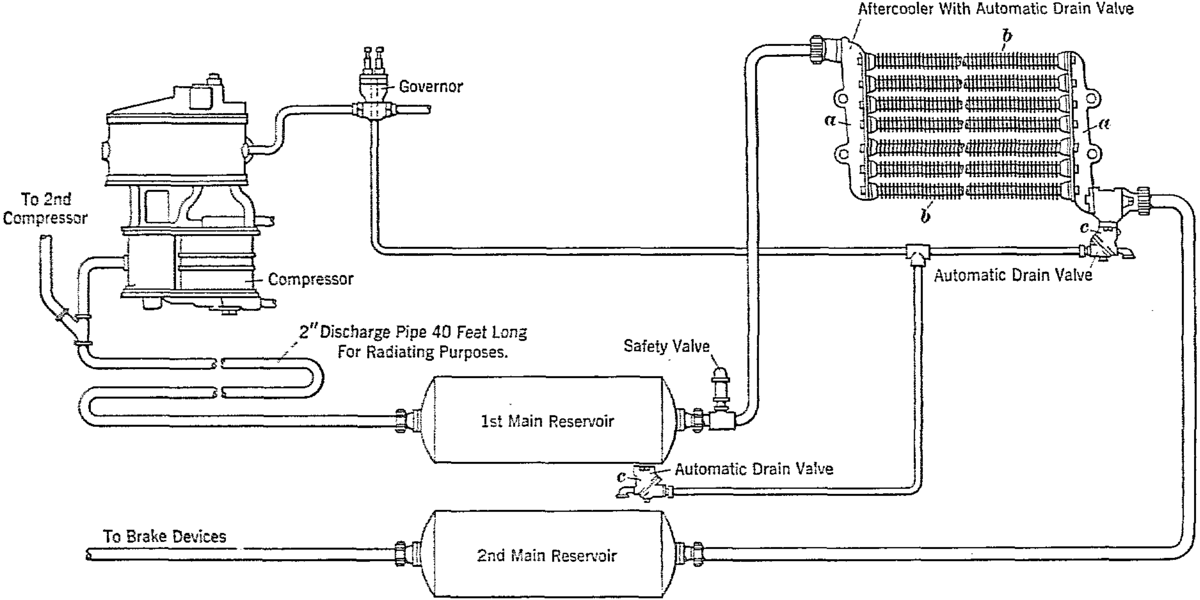


FIG. 45

of which is inserted a twisted stainless-steel ribbon for forcing the air against the tubing walls, and thereby providing a more efficient cooling action. Throttling orifices are provided in the inlet header to insure a uniform distribution of air flow through the tubes. An air-tight joint is made between each pipe and the header by a gasket shown in the detail in Fig. 47.

The automatic drain valve, Fig. 48, comprises a double-seated valve *a* arranged so that it can seat either at *b* or *c* depending on the direction of its movement, a diaphragm *d*, and a water-cooling chamber *e*, this surface of the drain valve being connected to the main reservoir. A spring *f* holds the valve to its lower seat *c* and the spring *g* holds the diaphragm away from contact with the valve *a* in the absence of air pressure in chamber *h*.

89. Operation of Aftercooler.—With the compressor in operation, the moisture is precipitated and collects in chamber *e*,



Aftercooler With Automatic Drain Valve
b
a
a
b
c
Governor
To 2nd Compressor
Compressor
Automatic Drain Valve
2" Discharge Pipe 40 Feet Long For Radiating Purposes.
Safety Valve
1st Main Reservoir
c
Automatic Drain Valve
To Brake Devices
2nd Main Reservoir

Fig. 46

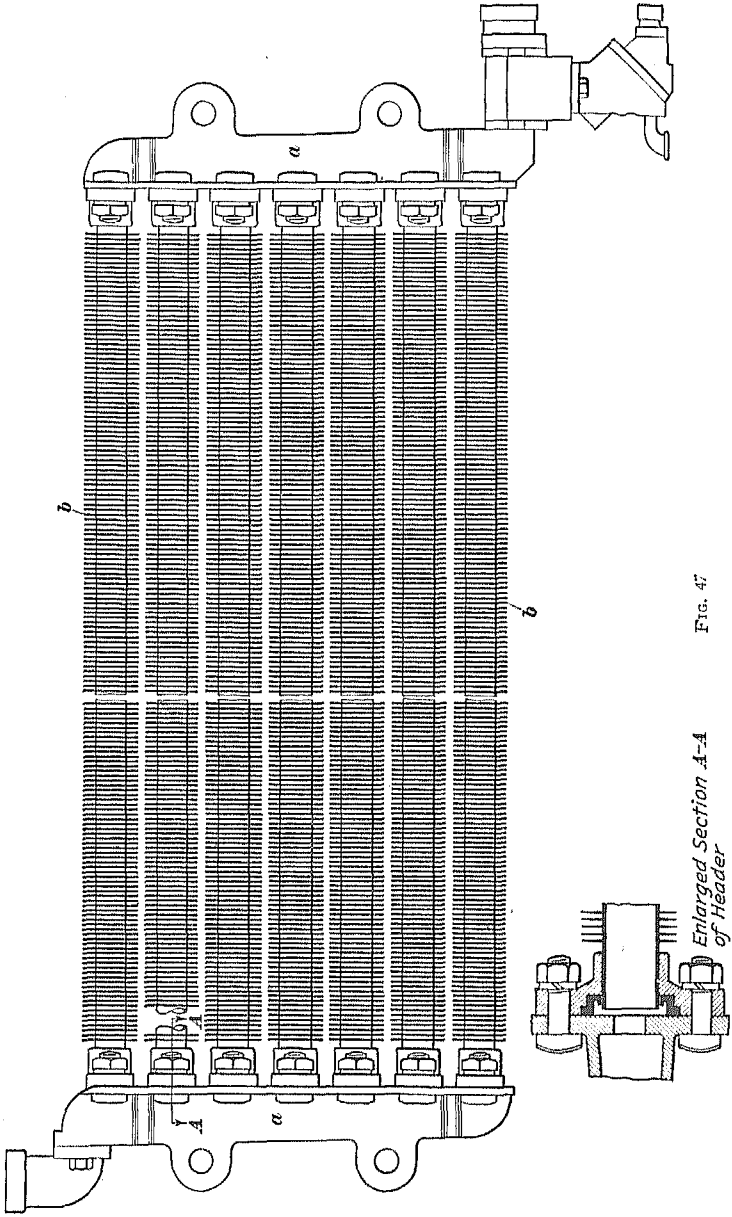


Fig. 47

Fig. 48, and then passes by the winged stem *i* of the valve *a* to chamber *j*. When the compressor governor operates to stop the compressor, air will flow to chamber *h*, deflecting the diaphragm *d* upward, and moving the double-seated valve from its lower seat *c* to its upper seat *b*. During this movement of the valve from its lower to its upper seat, the water chambers *e* and *j* are connected to the drain port so that the main reservoir

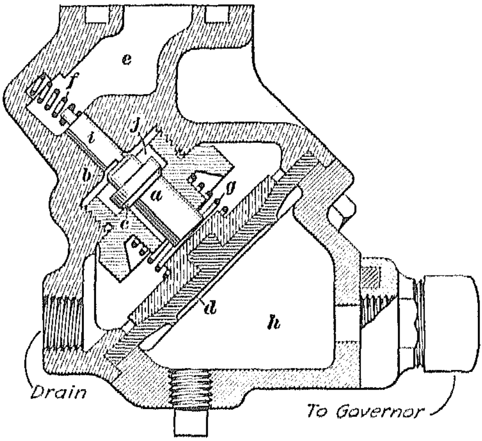


FIG. 48

pressure will quickly discharge to the atmosphere through the lower winged stem of the valve *a* the water that has collected in chambers *e* and *j*. The valve, when its upward movement is completed, is held on its upper seat by the air pressure on the diaphragm *d*, thus stopping the discharge of air. When the governor operates to start the compressor, the air is vented from chamber *h*. The action of the two springs *f* and *g* and the air pressure in chamber *e* then move the diaphragm downward until the valve contacts its lower seat *c*. During this movement of the valve from its upper to its lower seat, a definite amount of water is discharged from chamber *e*, as explained for the upward movement of the valve. Therefore, the drain valves automatically discharge water each time the compressor governor operates to either stop or start the compressor.

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

(PART 2)

Serial 5548B Edition 1

OPERATION OF BRAKE

PURPOSE OF CHARTS

1. The operation of the ET locomotive brake equipment will be studied by reference to the set of colored charts of the equipment that accompany the lesson papers on this brake equipment. Each chart shows the complete equipment in a different position, and the positions will be explained in the order in which the equipment is generally used.

Chart No. 2 shows the equipment in charging position, and Chart No. 3 shows the equipment in running position. Chart No. 4 shows the equipment in automatic service position, and Chart No. 5 in automatic service lap position. Chart No. 6 shows the equipment in release position after automatic service, and Chart No. 7 in holding position after automatic service. Chart No. 8 shows running and charging after automatic service and Chart No. 9 shows emergency position. Charts Nos. 10, 11, and 12 deal with the operation of the equipment by the independent brake valve.

In the preparation of the charts, a brake-pipe pressure of 110 pounds was assumed, and a main-reservoir pressure of 130 pounds in full-release, running, and holding positions at the time the compressor stops. The maximum-pressure head of the governor is set for 140 pounds and in lap, service, and emergency positions gives a main-reservoir pressure of this amount when the compressor stops.

2. Transparent views in color of the rotary valve of the automatic brake valve, and the independent brake valve, in position on their seats, are shown in Chart No. 13. The purpose of these views is to show the relation that exists between the ports and cavities in the rotary valve of the automatic and independent brake valve and their seats for the operating positions of the brake-valve handles. The rotary valves are shown in *yellow* and the rotary-valve seats, as shown by the ports that are cut vertically through the rotary valves, are white.

All of the red lines indicate ports and passages in the rotary valves, the full red lines indicating ports cut entirely through the valves; the dotted lines, ports or cavities in the face of the valves; and dot-and-dash lines, ports or cavities in the interior of the rotary valves. The ports in the rotary-valve seats are outlined in black, and passages below the surface of the seats that connect such ports are shown by dot-and-dash black lines.

AUTOMATIC OPERATION OF NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

3. Charging.—Chart No. 2 shows the brake system charging. The handle of the automatic brake valve is in full-release position, and the position of the hands on the large air gage indicates that the compressor has just been started. Air from the main reservoir passes through the high-pressure operating pipe to the chamber under the diaphragm of the high-pressure top of the AD governor, also main reservoir air passes through the M-3 reducing valve, and enters above the rotary valve *9* of the independent brake valve through ports *b* and *e* at a pressure of 45 pounds. Air from the main reservoir charges the application-valve chamber *a* of the distributing valve through the main-reservoir supply pipe and passage *a*.

The air from the main reservoir also passes through the M-3-A feed-valve and enters the feed-valve pipe and the automatic brake valve, reduced to brake-pipe pressure.

Chamber *A* in the automatic brake valve charges to main-reservoir pressure through passage *a* and the pipe connected to it. Chamber *A* in the brake valve above the rotary valve,

and chamber *a* in the distributing valve above the application valve, are always charged to the same pressure as in the main reservoir, as the free passage of air to these chambers is not affected by the position of the valves.

4. The passage of air through the automatic brake valve in full-release position, Chart No. 2, is as follows: Main-reservoir air passes from chamber *A* through port *a* in the rotary valve to port *b* and thence to the brake pipe on the engine and train, while chamber *D* and the equalizing reservoir charge through ports *j* and *g*. Air from the feed-valve pipe escapes into the emergency exhaust port *Ex* through cavity *f* and warning port *r*, the blow warning the engineer that the brake pipe will be overcharged if the brake valve is left in full-release position too long. Main-reservoir air flows through port *s* in the rotary valve and a passage *p* in the seat to the low-pressure operating pipe and to the diaphragm chamber of the low-pressure top of the governor. When the air pressure increases to the tension of the regulating spring in this top, the governor will operate and stop the compressor.

The air in the brake pipe, in addition to passing back to the brake pipe on the train, also passes ahead, and passing through the centrifugal dirt collector and the brake-pipe branch pipe, enters the chamber in the distributing valve in front of the equalizing piston *26* and moves the piston to release position as shown. The air then passes through feed groove *v* to the space surrounding the equalizing slide valve *31*, and also charges the pressure chamber through port *o*. The safety valve is connected to the application cylinder by port *l* in the equalizing valve seat, port *s* in the valve, and passage *h*. Chamber *B* of the emergency relay valve charges from the brake pipe through a branch pipe.

The locomotive brake cylinders are connected to the brake-cylinder exhaust and the atmosphere through ports *c*, *d*, and *e*.

The charging of the brake system may be briefly summarized by stating that the brake pipe, equalizing reservoir, and pressure chamber are being charged through the brake valve directly from the main reservoir.

5. Running.—Chart No. 3 shows the passage of air through the brake system in running position. In this position, charging of the brake system is completed by air from the feed-valve pipe, and the M-3-A feed-valve then automatically maintains a standard brake-pipe pressure. In running position of the automatic brake valve, air from the feed-valve pipe passes through port *d*, cavity *f* in the rotary valve *6* and port *b* to the brake pipe, while the equalizing reservoir charges from the brake pipe through port *c*, cavity *k*, and port *g*.

From the brake pipe, air passes to the distributing valve and, feeding by groove *v*, completes the charging of the pressure chamber. The application cylinder *g*, the application chamber, and the application-cylinder pipe are connected by ports *h* and *w* and cavity *k* in the equalizing slide valve *31* to exhaust port *i* and the distributing-valve release pipe when valve *31* is in release position, and thence by ports *a* and *c* and cavity *f* in the rotary valve *9* of the independent brake valve to the release pipe, and to the emergency exhaust port *Ex* by way of port *l* and passage *h*. The emergency exhaust port is then the outlet for any leaks into the application chamber or cylinder when the equipment is not being operated.

In running, the locomotive brake cylinders or the cylinders on the engine and the tender are connected to the brake-cylinder exhaust through ports *c*, *d*, and *e*, as in charging.

Running position may be summarized by stating that the brake pipe, equalizing reservoir, and pressure chamber are maintained at an equal pressure which is dependent on the adjustment of the M-3-A feed-valve.

6. Automatic Service.—Chart No. 4 shows the positions assumed by the parts of the equipment affected when the automatic brake valve is placed in service position. This position of the brake valve gradually reduces the pressure in the brake pipe, thereby causing the distributing valve to apply the locomotive brake, and the triple valves to apply the brakes on the cars.

When the brake-valve handle is placed in service position, air from chamber *D* above the equalizing piston, and from the equalizing reservoir passes through the preliminary exhaust

port *e* in the rotary-valve seat to port and passage *h*, and then through port *o* to the emergency exhaust port *Ex*. The greater pressure below the equalizing piston now moves it upwards and the lower portion of its stem or the equalizing discharge valve opens the passage in the service-exhaust fitting and permits the air in the brake pipe to escape.

The reduction in brake-pipe pressure reduces the pressure in front of the equalizing piston *26*, and the greater pressure in the pressure chamber forces the piston forwards and closes the feed groove *v*, and at the same time moves the graduating valve not only to uncover the upper end of service port *z*, *but* also to connect the upper ends of ports *r* and *s* through cavity *t*. By this time the collar of the piston stem engages the equalizing slide valve *31* and moves it to service position as shown, the movement of the piston being arrested when the knob on the piston strikes the graduating stem *44*, the graduating spring *46* then preventing any further movement. The ports that are now connected by the equalizing slide valve are as follows, it being recalled that there are three ports *h* in the equalizing slide-valve seat. The lower end of port *z* registers with port *h*, cavity *n* connects a second port *h* to port *w* in the valve seat, the lower end of port *r* connects with a third port *h*, and the lower end of port *s* registers with port *l*. The air from the pressure chamber passes through the above named ports and cavities to four different points: to the application cylinder, to the application-cylinder pipe, to the application chamber, and to the safety valve.

7. The admission of air from the pressure chamber to the application cylinder forces the application piston *10* to the right, the arrangement of the exhaust valve *16* and the application valve *5* being such that the exhaust valve closes the exhaust ports *c* and *d* before the application valve opens. When the application piston has moved far enough so that the stem *19* engages the cap nut, and thus compresses the graduating spring *20*, the application valve opens and allows main-reservoir air to pass through port *a* into chamber *b* and through passage *c* to the brake cylinders on the engine and tender, and applies

the brakes. The air passing to the brake cylinders also enters chamber *b* behind the application piston through port *u* and the collar on the stem of the application valve, and thereby steadies the movement of the piston. The pressure developed in the application cylinder and therefore in the brake cylinders will always be limited to the adjustment of the safety valve, which opens at 68 pounds. In service position, the vent valve on the tender operates as previously explained.

The passage of air through the equipment as shown in Chart No. 4 is therefore as follows: Air is exhausting from the equalizing reservoir and the brake pipe; pressure-chamber air is passing to the application chamber, application cylinder, application-cylinder pipe, and the safety valve; and air from the main reservoir is passing to the brake cylinders.

8. After the desired reduction has been made in chamber-*D* pressure, the brake-valve handle is moved to lap position as shown in Chart No. 5. This closes the preliminary exhaust port and stops the exhausting of air from chamber *D*. The escape of brake-pipe air continues at the service exhaust until the brake-pipe pressure below the equalizing piston is slightly less than chamber-*D* pressure above it, when the piston will move down and seat the equalizing discharge valve as shown.

After the discharge of brake-pipe air at the brake valve has stopped, the air from the pressure chamber will continue to pass to the application chamber and cylinder as already explained until the pressure in the pressure chamber is a trifle less than that in the brake pipe. Piston *26* is then moved to the left by the greater brake-pipe pressure, the graduating valve moving with it, until the movement is stopped by the collar on the piston engaging the front end of the equalizing slide valve. The graduating valve now closes the upper ends of ports *z* and *s* and thereby prevents the further passage of air through the equalizing slide valve. Closing port *s* prevents a possible leak at the safety valve from reducing the pressure in the application cylinder and releasing the brake.

9. After the equalizing portion of the distributing valve goes to lap position, main-reservoir air continues to pass

through the application valve *5* to the brake cylinders, as already explained, until the pressure in the chamber behind the application piston is about equal to that in the application cylinder *g*. The application-piston graduating spring *20* then expands and moves piston *10* to the left until valve *5* cuts off the passage of air from chamber *a* to chamber *b* as shown in Chart No. 5, and any further movement of the parts is prevented by the resistance offered by exhaust valve *16* and spring *20* which has expanded to normal position.

In service position, as well as in lap and emergency positions, main-reservoir air passes through port *j* in the rotary valve to port *d* and the feed-valve pipe. This connection has no bearing on the action of the brake equipment but is one that cannot be prevented when the ports are arranged for the proper operation of the brakes in the various positions of the brake valve.

10. Automatic Service Lap.—Chart No. 5 shows the automatic brake valve and the distributing valve in lap position. In lap position, the brake is held applied, as the passage of air through the brake valve is prevented. But with plug *B* in the side of the brake valve removed, the locomotive brake will release following a movement to release position and back to lap.

As the application piston *10* is now balanced between brake-cylinder pressure on one side and application-cylinder pressure on the other, any variation in either pressure will cause the piston to move toward the lower pressure. Therefore, if brake-cylinder leakage reduces the pressure behind the piston the higher pressure in the application cylinder will cause piston *10* to move valve *5* to the right to open position, and thereby admit main-reservoir air to the brake cylinder, until the leakage is restored, when the piston and valve will move back to lap position. Provided that brake-cylinder leakage is less than the compressor can supply, the brake-cylinder pressure will always be maintained equal to that in the application cylinder.

This feature of the distributing valve of automatically holding the brake applied is known as the pressure-maintaining feature. However, a leak from the application cylinder will cause the locomotive brake to release, as the movement of the

application piston *10* will now be to the left, or to release position, and the exhaust valve will exhaust the brake-cylinder air through ports *d* and *e* to the brake-cylinder exhaust.

11. *The reason for permitting air from the application cylinder to enter the application-cylinder pipe in service position is to make it possible to release the locomotive brake by the independent brake valve, if desired, without affecting the brakes on the train.*

Air from the application cylinder is not permitted to enter *the distributing-valve release pipe in service; for if it were,* the brake would not apply on the second engine of a double header, because with both brake valves in running position the application cylinder would be open to the atmosphere at the automatic brake valve. Also, for the same reason, with one engine, the brake would not apply in the event of the brakes being applied by means other than the brake valve, such as a break-in-two, etc., unless the brake valve was quickly lapped.

12. If another reduction in brake-pipe pressure is made, as shown in Chart No. 4, the greater pressure in the pressure chamber will again move the equalizing piston *26* to the right until it strikes the graduating stem *44*. Since the equalizing slide valve *31* is already in service position, the movement of piston *26* will only move the graduating valve *28* which opens the upper end of port *z*, and connects the upper ends of ports *r* and *s* through cavity *t*. Communication is thereby again reestablished between the pressure chamber, the application cylinder and chamber, and the safety valve. The application portion again operates and increases the pressure in the brake cylinders an amount equal to the additional increase in application-cylinder pressure. The distributing valve laps as shown in Chart No. 5, when the pressure in the pressure chamber and the brake pipe, and in the brake cylinders and the application cylinder are approximately equal.

The brake-pipe pressure can be reduced and the locomotive brake applied harder until the pressure in the pressure chamber equalizes with the pressure in the application chamber and cylinder. The volume of these chambers is such that a reduc-

tion in pressure of 20 pounds from a brake-pipe pressure of 70 pounds will cause the pressures in them to equalize at 50 pounds, which corresponds to the brake-cylinder pressure developed on a car on which the piston in the brake cylinder has an 8-inch travel. With a brake-pipe pressure of 110 pounds, a brake-pipe reduction of about 27 pounds will apply the locomotive brake to the setting of the safety valve, or 68 pounds.

13. **Release After Automatic Service.**—Chart No. 6 shows the position of the parts affected and the distribution of pressure after the automatic brake valve has been placed in full-release position after an application of the brake. This operation releases the train brakes but retains the brake on the locomotive. The flow of air through the brake valve is the same as explained in Chart No. 2, the brake pipe and the equalizing reservoir charging from the main reservoir, and air from the feed-valve pipe escaping through the warning port. Main-reservoir air passing to the brake pipe increases the brake-pipe pressure and forces the equalizing piston *26* and the attached valves to full-release position, and the pressure chamber recharges through the feed groove *v*. Cavity *k* in the equalizing valve *31* connects ports *h* and *w* with exhaust port *i*, thereby allowing the air in the application chamber and cylinder to pass to the distributing-valve release pipe and the release pipe, as these two pipes are connected by cavity *f* in the rotary valve *9* of the independent brake valve. However, as port *l*, the termination of the release pipe at the automatic brake valve, is blanked by the rotary valve, the air cannot escape from the application chamber and cylinder, consequently application piston *10* and valves *5* and *16* remain in lap position and the brake on the locomotive remains applied, although the equalizing portion and all the brakes in the train are in release position.

14. **Holding After Automatic Release.**—The brake valve must be placed in holding position as shown in Chart No. 7 if it is desired to hold the locomotive brake applied and still not overcharge the brake pipe and equalizing reservoir, as

would result from leaving the brake valve in full-release position. In holding position, the rotary valve of the automatic brake valve still blanks the release pipe, thus preventing the escape of air from the application cylinder and holding the locomotive brake applied as in release position; but any liability of the brake pipe becoming overcharged is prevented, as the brake pipe is now charged up to standard pressure from the feed-valve pipe through the automatic brake valve, as explained for running position. The equalizing reservoir is also recharging from the brake pipe. Holding position can be eliminated, if desired, by removing the plug shown in passage *l'* in the rotary-valve seat.

15. Running Position After Automatic Service.—Chart No. 8 shows the effect of moving the automatic brake valve from holding position to running position. The charging of the brake pipe, equalizing reservoir, and pressure chamber in running position has already been explained, therefore it is only necessary to explain how this position causes the locomotive brake to release.

Moving the brake valve to running position allows the air that was retained in the application chamber, application cylinder, the application-cylinder pipe, the distributing-valve release pipe, and the release pipe, in full-release and holding positions, to escape to the atmosphere at the automatic brake valve through port *l*, port *h*, and cavity *o* in the rotary valve and the emergency exhaust port *Ex.* The pressure in chamber *b* behind the application piston *10*, moves the piston and therefore the exhaust valve, to the left until the valve opens ports *e* and *d*. This permits the air in the brake cylinders to pass through the brake-cylinder exhaust port to the atmosphere, and the locomotive brake releases.

16. Emergency.—Chart No. 9 shows the effect of placing the automatic brake valve in emergency position. In this position, air from the brake pipe passes through passage *b* and port *c*, thence through a cavity *x* in the rotary valve, as shown by the arrows, to the emergency exhaust port *Ex*; and as these openings are large, the effect of connecting them to the atmos-

phere is to cause a sudden and heavy discharge of brake-pipe air, which results in an emergency application of all brakes. The pressure in the equalizing reservoir and chamber *D* also escapes through the emergency exhaust port by the way of ports *g* and *t*. The equalizing piston *15* does not rise, because brake-pipe air escapes more quickly below the piston than from chamber *D* above it.

The reason for the port arrangement for draining the equalizing reservoir in emergency position is to release the heavy strain on the piston stem and the valve seat resulting from the excessive load that would otherwise be imposed upon the solid type of equalizing piston. This condition does not exist with the collapsible type of equalizing piston, but the brake valve has not been modified to eliminate these ports, as they have no effect on the brake operation.

The sanding port *z* in the rotary valve is in register with port *y* in the seat, this connection permitting main reservoir air in chamber *A* to flow to the face of the emergency relay piston *7* and the attached small piston valve *4* is then forced to the right and unseated and spring *11* is compressed. The brake-pipe pressure in chamber *B* now exhausts rapidly to the atmosphere and thus assists the reduction in pressure that is being made at the brake valve.

The heavy reduction in brake-pipe pressure in front of the equalizing piston *26* causes the now much higher pressure in the pressure chamber to move the piston its full travel and to seat on the gasket. The knob on the piston strikes the graduating stem *44*, and moves it forward, and compresses the graduating spring *46*.

When the equalizing piston *26* moves the equalizing slide valve *31* to emergency position, the end of the valve opens port *h* and the third port *h* is connected to port *l* and the safety valve by the way of ports *q* and *r*, these two latter ports being connected by a restricted passage. These port connections permit air from the pressure chamber to pass to the application cylinder, application-cylinder pipe, and the safety valve; but the air cannot pass to the application chamber, because the equalizing slide valve blanks port *w*. The admission of pressure-chamber air

to the application cylinder causes the application portion to operate and admit air from the main reservoir to the brake cylinders in the same manner as in a service application, with the exception that the movement of the parts of the application portion is more rapid and port *a* opens wider.

17. In emergency position, Chart No. 9, port *j* in the rotary valve registers with port *d* in the seat, this port having a groove extension that connects with cavity *k*. Main-reservoir air then flows through port *j* to cavity *k*, then through a small maintaining port to cavity *n* and port *u*, and thence to the application-cylinder pipe and the application cylinder. The size of the small port connecting ports *q* and *r* in the equalizing slide valve is so proportioned to the size of the maintaining port in the automatic brake valve that the pressure flowing from the main reservoir to the application cylinder will escape through the safety valve at a rate which, while giving a higher brake-cylinder pressure than obtained in full service, will be less than main-reservoir pressure. With a brake-pipe pressure of 70 pounds, the pressure in the pressure chamber and the application cylinder equalizes at 65 pounds and the inflow of main-reservoir air increases the pressure to and maintains it at 68 pounds.

With a brake-pipe pressure of 110 pounds, as used in passenger service, the pressure equalizes at 93 pounds and is reduced by the safety valve to about 75 pounds. The pressure is maintained at this amount, as the inflow of air from the main reservoir at the higher pressure is equal at 75 pounds to the outflow through the small port in the equalizing slide valve. The admission of main-reservoir air to the application cylinder not only insures a shorter stop, but prevents any liability of the locomotive brake releasing due to leakage from the application cylinder or cylinder pipe. Also, the higher brake-cylinder pressure developed will correspond to that obtained on passenger trains as compared to freight trains. The reason that application-cylinder air is not admitted to the distributing-valve release pipe is the same as already given when considering service position. The brake-pipe vent valve on the tender operates in emergency as previously explained.

The application portion returns to lap position as soon as the pressures in the application cylinder and in the brake cylinders are about equal.

18. **Emergency Lap.**—Emergency lap position is not illustrated because the distribution of pressure is the same as in Chart No. 9, the only difference being that the application valve 5 in emergency lap position is closed, whereas, in Chart No. 9, this valve is open.

19. **Release Position After Emergency.**—Placing the brake-valve handle in full-release position after an emergency application results in the brake-cylinder pressure being reduced from 68 pounds to 15 pounds, which is retained until the brake valve is placed in running position. The reason for this reduction in pressure is as follows: The increase in brake-pipe pressure forces the equalizing portion of the distributing valve to release position as shown in Chart No. 6. In this position cavity *k* in the equalizing slide valve connects port *h* to ports *w* and *i* thereby allowing the air in the application cylinder to pass to the application chamber and to the distributing valve release pipe in which there is no pressure, the result being that the pressure in the application cylinder will reduce from 68 pounds to 15 pounds. The application piston is then moved by the greater pressure in the brake cylinders toward release position, and the exhaust valve permits the air in the brake cylinders to escape at the brake-cylinder exhaust until the pressure therein is slightly less than 15 pounds. The greater pressure in the application cylinder then moves the application piston to the right until the exhaust valve is in lap position, which prevents the further exhaust of air. Placing the brake-valve handle in running position will complete the release of the brake.

The passage of main-reservoir air to the emergency relay valve stops when the automatic brake valve is moved out of emergency position. The air in chamber *A* of the relay valve and in the connecting pipe will escape through a small port in the piston to the exhaust thereby permitting the spring *11* to seat piston *4* and break the connection between the brake pipe and the atmosphere.

INDEPENDENT OPERATION OF NO. 6 ET LOCOMOTIVE BRAKE

20. **Running.**—Chart No. 3 shows the independent brake valve in normal, or running, position. In running position, as well as in all other positions of the independent brake valve, air at a pressure of 45 pounds passes from the reducing-valve pipe through ports *b* and *e* in the rotary valve *9* to the chamber above the valve.

In running position, cavity *f* in the rotary valve connects ports *a* and *c* and thereby connects the ends of the distributing-valve release pipe and the release pipe. In running position of the automatic brake valve, cavity *h* in the rotary valve connects port *l* and the end of the release pipe to the emergency exhaust port. Therefore, running position of both brake valves in combination with release position of the equalizing slide valve connects the application chamber and cylinder to the atmosphere through the emergency exhaust port *Ex* in the automatic brake valve.

21. **Independent Quick Application.**—Chart No. 10 shows the application of the locomotive brake by the independent brake valve in quick-application position. In this position air from the reducing-valve pipe passes from port *b* thence through an interior cavity *e* in the rotary valve of the independent brake valve to port *d* and the application-cylinder pipe, and then to the application cylinder through passage *h*. The application portion of the distributing valve operates in exactly the same way as in automatic service, this portion going to lap position, as shown in Chart No. 11, when the brake-cylinder pressure approximates application-cylinder pressure.

Air from the application-cylinder pipe also passes from port *h* to cavity *k* in the equalizing slide valve *31*, and to the application chamber through port *w*, and thence through port *i* to the distributing-valve release pipe. The air cannot pass to the release pipe, as the rotary valve of the independent brake valve breaks the connection between the pipes, and thereby prevents the escape of air at the emergency exhaust port. The

distributing-valve release pipe could be piped directly to the automatic brake valve were it not for the fact that during an independent application the air would escape at the emergency exhaust port. The safety valve is connected to the application cylinder through port *h*, port *s* in the equalizing slide valve, and port *l*.

22. **Independent Slow Application.**—It is unnecessary to illustrate slow-application position, as the only difference between it and quick application is a slower application of the brake, because the air now passes to the application-cylinder pipe through a smaller opening in the rotary valve than in quick-application position In slow-application position, the air from port *b* passes through the interior passage in the brake valve shown in Chart No. 10 and from thence through a small passage and port, not shown, to the application cylinder pipe.

23. **Independent Lap.**—Chart No. 11 shows independent lap. Moving the independent brake valve to lap position breaks the connection that existed between ports *b* and *d* in quick-application and slow-application positions and thereby prevents the passage of air to the application-cylinder pipe. The application portion of the distributing valve goes to lap position in the same manner as after automatic service. The maximum pressure obtained in the application cylinder and therefore in the brake cylinders cannot exceed the adjustment of the reducing valve, or 45 pounds.

24. **Independent Release After Independent Application.** Chart No. 8 will serve to illustrate the release of the locomotive brake after an independent application. The brake is released by placing the independent brake valve in running position. In this position, cavity *f* in the rotary valve connects the upper end of the distributing-valve release pipe to the release pipe, which is open to the atmosphere at the automatic brake valve. This connection permits the air in the distributing-valve release pipe, and therefore in the application cylinder and chamber, to pass through the release pipe to the emergency exhaust port *Ex* of the automatic brake valve.

The connection between the application cylinder, the application chamber, the application-cylinder pipe, and the distributing-valve release pipe is made through ports *h* and *w*, cavity *k* in the equalizing valve, and exhaust port *i*.

The application portion of the distributing valve then operates and exhausts the air from the brake cylinders, as already explained under automatic operation. It is absolutely essential for the equalizing slide valve to be in release position before running position of the brake valve will release the locomotive brake, as any other position prevents the air from the application cylinder from entering the distributing-valve release pipe through exhaust port *i*.

The foregoing explains why an improperly working feed-valve or a slightly overcharged brake pipe will sometimes prevent running position from releasing the locomotive brake, as it permits the brake-pipe pressure to reduce and thereby moves the equalizing portion out of release position.

25. Independent Release After Automatic Service.—It is sometimes necessary, due to the tires overheating or the drivers sliding, to release the locomotive brake without releasing the brakes on the train. Chart No. 12 shows the locomotive brake being released by the independent brake valve after being applied by the automatic brake valve. This chart shows the automatic brake valve in lap position, and the equalizing portion of the distributing valve is in lap position. Before the release of the locomotive brake, the application portion would also be in lap position.

When the independent brake valve is placed in release position, cavity *g* in the rotary valve connects ports *d* and *h*, and the air in the application chamber and cylinder escapes through the application-cylinder pipe to the atmosphere at *Ex*. The application portion then operates as already described and releases the locomotive brake by exhausting the air from the brake cylinders through the brake-cylinder exhaust.

The exhausting of application-cylinder and application-chamber air does not affect the air in the pressure chamber, for although passage *z* in the equalizing slide valve is connected to

port *h*, yet the graduating valve *28* has the upper end of port *s* closed, and the equalizing portion of the distributing valve therefore does not move.

26. Releasing the locomotive brake under the conditions just mentioned does not imply that the brake will remain released; for, after the brake-valve handle is returned to running position, the brake after a short interval will reapply. The reapplication of the locomotive brake is due to brake-pipe leakage, which is not supplied in lap position of the automatic brake valve. The equalizing piston then moves the graduating valve, which opens the upper end of port *s*, thereby permitting pressure-chamber air to pass to application chamber and cylinder and to reapply the brake. To insure that the brake shall remain released, it is necessary therefore to keep the independent brake-valve handle in release position.

Chart No. 12 shows that port *l* in the rotary valve registers with port *k* in the seat of the independent brake valve, thus allowing air from the reducing-valve pipe to escape to the atmosphere in release position. The purpose of this is to give warning when the return-spring arrangement becomes defective and fails to return the brake-valve handle from release to running position. The brake could not be applied with the handle in release position, as the application-cylinder pipe is connected to the atmosphere.

DISTRIBUTING-VALVE RELEASE PIPE

27. Arrangement and Purpose.—The release pipe will be considered as being a part of the distributing-valve release pipe, as the former is merely a continuation of the latter. The distributing-valve release pipe begins at the exhaust port *i*, Chart No. 3, in the equalizing slide valve seat and terminates in port *l* in the rotary-valve seat of the automatic brake valve.

The purpose of the distributing-valve release pipe is to convey air from the application cylinder of the distributing valve to the emergency exhaust port of the automatic brake valve and thus permit a release of the locomotive brake in running position of this brake valve. Provision is made for cutting off the escape of air at three different points, these points being at either brake

valve and at the equalizing slide valve. When the pipe is closed at one of these points, it is still open through the other two.

Cutting off the escape of air from the distributing-valve release pipe at the automatic brake valve permits the locomotive brake to be held applied in full-release and in holding positions. Breaking the communication at the independent brake valve prevents the escape of air from the application cylinder to the emergency exhaust port of the automatic brake valve during independent brake applications. Breaking of the communication at the distributing valve by means of the equalizing slide valve permits the brake to be applied on an engine other than the one that is in control of the brakes.

A free opening from the application cylinder and the application chamber through the distributing-valve release pipe to the atmosphere exists only when the equalizing portion of the distributing valve is in release position and both brake valves are in running position.

Application-cylinder air is held in the distributing-valve release pipe during independent brake applications. In full release and holding positions after automatic service both sections of the pipe contain application-cylinder air.

28. **Purpose of Application-Cylinder Pipe.**—The purpose of the application-cylinder pipe is to convey air from the independent brake valve to the application chamber and application cylinder and thereby apply the brake, and to exhaust the air therefrom when it is desired to release the locomotive brake independent of the train brakes. The branch pipe to the automatic brake valve permits main-reservoir air to pass to the application cylinder in emergency position. The application-cylinder pipe is always in communication with the application cylinder, and contains air at application-cylinder pressure whenever the brake is applied.

DISORDERS OF EQUIPMENT

BLOWS

29. **Blow at Brake-Cylinder Exhaust Port.**—A constant blow at the brake-cylinder exhaust port when the brake is released is due to a leak of air from the main reservoir or the

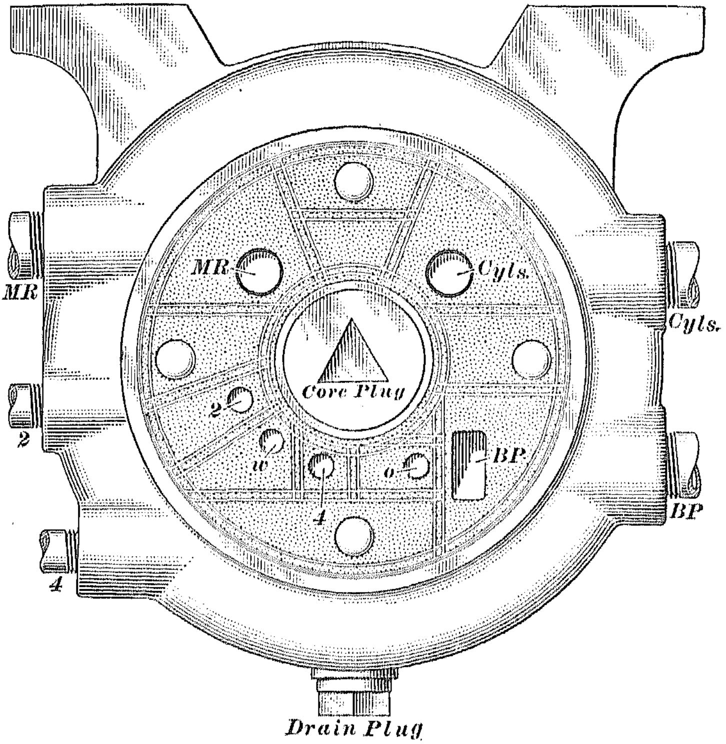


FIG. 1

brake pipe into the brake cylinder. This may result from any of the following causes: The application valve may leak; there may be a leak in the distributing-valve gasket, Fig. 1, between the main reservoir and the brake-cylinder port, or between the

brake-pipe port and the brake-cylinder port; or the cylinder-cap gasket *25*, Fig. 2, may leak and allow brake-pipe air to enter passage *m*. However, the most probable cause is that the application valve is leaking.

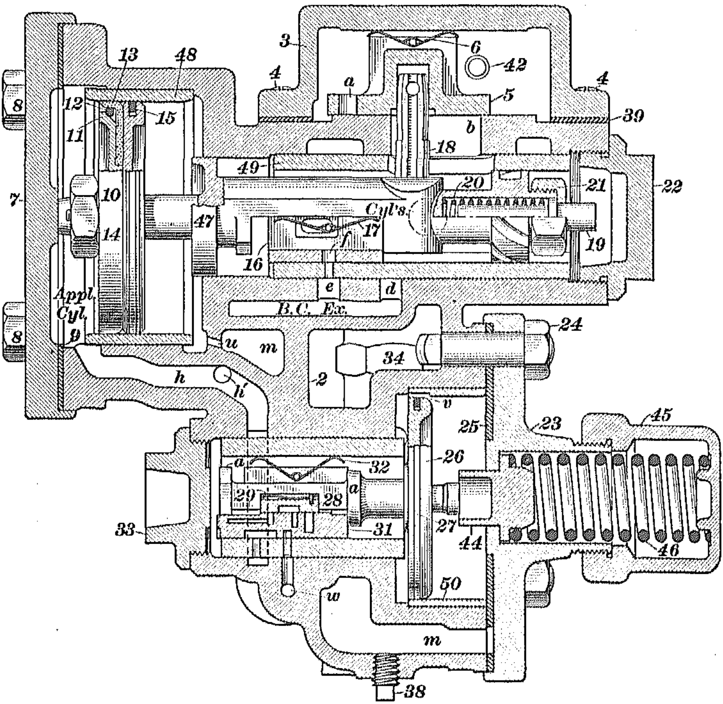


Fig. 2

30. When the brake is applied, and the distributing valve is in lap position, a leak of main-reservoir air into the chamber behind the application piston at any of the points mentioned in the preceding article will cause an intermittent blow at the brake-cylinder exhaust port, provided the brake cylinders are comparatively tight and there is no leakage from the application cylinder. The blow at this time results because the leak increases the pressure in the brake cylinders above the pressure in the application cylinder, thereby causing the application piston to move the exhaust valve and open the exhaust ports. The blow continues until the pressure in the brake cylinders is

reduced to application-cylinder pressure, when the application piston will move the exhaust valve so as to close the exhaust ports.

A leak from the brake pipe into the space behind the piston will produce the same effect if the brake is not fully applied.

In the event of brake-cylinder leakage, a leak from the main reservoir or brake pipe may not increase the brake-cylinder pressure sufficiently to cause a blow.

A leak in the cylinder-cap gasket may under certain conditions cause the brake-cylinder air to leak into the brake pipe and cause an intermittent blow at the service exhaust port. For example, if the brake is applied by the automatic brake valve, and the valve is left in lap position for some time, brake-pipe leaks will continue to apply the brake, and the pressure in the brake pipe will finally reduce below the pressure in the brake cylinders. Brake-cylinder air leaking into the brake pipe through the gasket causes the application portion to operate and supply the leak. This results in the brake-pipe pressure being increased above the pressure in the equalizing reservoir, and the equalizing piston will unseat at intervals and cause a blow at the service exhaust.

31. Whether the blow at the brake-cylinder exhaust port is due to a leak from the main reservoir or from the brake pipe can be determined by closing the cut-out cock in the distributing-valve supply pipe. If the blow stops, the leak is from the main reservoir; but if it continues, the leak is from the brake pipe. An inspection is necessary to determine whether the distributing-valve gasket or the cylinder-cap gasket is at fault.

32. Blow at Emergency-Exhaust Port.—A continuous blow at the emergency-exhaust port of the automatic brake valve with both brake valves in running position and the distributing valve in release position is generally due to an equalizing slide-valve leak which allows pressure-chamber air to enter any of the ports in the valve seat, and escape through the distributing-valve exhaust port *i*, Chart No. 3. The blow may also be due to a leak at the graduating valve, or to a leak in the distributing-

valve gasket, Fig. 1, that permits main-reservoir or brake-pipe air to pass into the application cylinder through the large opening in the center or into ports *2*, *w*, or *4*, and therefore into the application cylinder, application chamber, or the distributing-valve release pipe. In addition to the above causes the blow may be due to a leak at the rotary valves in the brake valves, or a leak in the pipe-bracket gasket in the independent brake valve, or the two gaskets in the automatic brake valve. The gaskets, however, rarely leak if they are properly applied and the nuts and capscrews are drawn up evenly.

33. The reason that a leak under the above-mentioned conditions causes a blow at the emergency exhaust port is that the application cylinder, application-cylinder pipe, and application chamber are connected through the exhaust port *i* to the distributing-valve release pipe, which in turn is connected through the release pipe to the emergency exhaust port, as shown in Chart No. 3. If the leak exceeds the capacity of exhaust port *i*, the pressure accumulating in the application cylinder will apply the brake. When the brake is applied by either brake valve, the escape of air from the distributing valve at the emergency exhaust port of the brake valve is prevented, and the leak then acts to increase the pressure in the application cylinder, and thus to apply the brake harder than intended, or, as usually expressed, the brake-cylinder pressure "creeps up."

34. Pressure-chamber air leaking past the equalizing slide valve, in addition to causing a blow at the exhaust port, will have a tendency to cause the equalizing portion of the distributing valve to move to release position after an automatic service application, as the leak reduces the pressure-chamber pressure below the brake-pipe pressure. The brake then would release only on the second engine of a double header, as the release pipe on the leading engine is closed by the automatic brake valve. Any tendency for the leak to cause the equalizing piston to move to release position is generally offset by brake-pipe leakage, and as a result the piston will not move. A leaking graduating valve will have the same effect.

35. Determining Location of Leak.—To determine whether a leak is from the brake valves or the distributing valve, leave the independent brake valve in running position and place the automatic brake valve in holding position, which closes the release pipe; then disconnect the distributing-valve release pipe and the application-cylinder pipe at the distributing valve. Next, unless the blow can be heard, close the openings at the distributing valve with the fingers for about 30 seconds, and then uncover one opening by lifting a finger. If air pressure has accumulated, the leak is in the equalizing valve, the graduating valve, or the distributing-valve gasket, and it will generally require an inspection to determine which is at fault, although it is usually the equalizing valve.

However, if the brake pipe is comparatively tight, as with the engine alone, the equalizing valve can be tested by making a light automatic service application, lapping the brake valve, and closing the double-heading cock. After a short interval, place the automatic brake valve in running position. If the brake releases, it indicates that the equalizing valve or the graduating valve leaks, and has caused the equalizing portion to move to release position.

A leak from the brake valves can be determined by temporarily closing the ends of the pipes with the fingers as before mentioned. To determine which brake valve is at fault, if the blow is from the application-cylinder pipe, it will be necessary to disconnect this pipe at both brake valves, and test the openings. The automatic brake valve should be tested in running, holding, and lap positions, and the independent brake valve in running and lap positions.

If the leak is from the distributing-valve release pipe, and it stops when the independent brake valve is lapped, the fault is probably with the automatic brake valve, as lapping the valve breaks the connection between the two release pipes. If the blow continues, the independent brake valve is at fault. A leak through the brake-valve gaskets can sometimes be stopped by screwing down on the nuts and capscrews.

DISTRIBUTING-VALVE DISORDERS

36. Usual Disorders.—The usual disorders that affect the operation of the distributing valve in addition to those already mentioned are as follows: Application-piston packing ring or leather leaking; cylinder-cover gasket leaking; safety valve leaking; drain plugs leaking; equalizing-piston packing ring stuck; exhaust valve leaking; equalizing-piston graduating spring broken.

37. Application-Piston Packing Ring or Leather Leaking. It should be noted that the packing ring *15*, Fig. 2, on the application piston serves to make an air-tight joint during both the application and the release movement of the piston, whereas the packing leather 13 functions during the application movement only. The effect of a leak at the application-piston packing ring *15* will be indicated by a slow release of the locomotive brake after a light application as shown by a longer discharge of air than otherwise at the emergency exhaust port of the automatic brake valve as well as at the brake-cylinder exhaust port when the brake is releasing or when the brake is partly released and the independent brake valve is lapped.

The reason why a leak by the ring is more apparent with a low brake-cylinder pressure, is that the higher brake-cylinder pressure will overcome the friction of the application portion, even with a leak past the application piston, while a lower brake-cylinder pressure will fail to do so. This explains why increasing the brake-cylinder pressure will cause the brake to release after a failure to do so following a light application. If the distributing valve is in good order, the air should be discharged from the brake cylinders in about 3 seconds.

To test for a leak by both the packing ring and the leather, because they cannot be tested separately, close the cut-out cock in the main reservoir supply pipe, and the cut-out cock in the brake-cylinder pipe to reduce the volume as much as possible, remove the plug *38*, and place the independent brake valve in slow-application position. In the event of a leak, a steady blow will occur at the open plug hole.

38. Cylinder-Cover Gasket Leaking.—A leak in the cylinder-cover gasket *9*, Fig. 2, will permit the pressure in the application cylinder to escape, and the locomotive brake will then release after being applied with either brake valve and the valve lapped. However, the leak will generally be kept supplied with the independent brake valve in slow-application position, and the locomotive brake is therefore prevented from releasing.

39. Safety Valve Leaking.—If the valve is leaking on its seat, or if the safety valve leaks where it is screwed into the distributing valve, or if the spring has no tension, the locomotive brake may not apply with the independent brake valve or if applied will release, as the air entering the application cylinder has direct access to the safety valve through the equalizing valve.

When the automatic brake valve is being used, a somewhat less pressure will be developed in the application cylinder than otherwise, provided the leak at the safety valve is less than the amount of air passing through the equalizing valve from the pressure chamber to the application cylinder and chamber. After the equalizing portion has lapped, the graduating valve, if tight, cuts off the application cylinder from the safety valve, and the brake will be held applied. However, the brake will release with the automatic brake valve in release or holding position, as the equalizing valve is then in release position and connects the application cylinder and chamber to the safety valve.

To test the safety valve, place the automatic brake valve in emergency position and note the pressure on the brake-cylinder gage when the safety valve opens; this should be 68 pounds.

40. Leaky Drain Plugs.—A leak at the drain plug, Fig. 1, in the application chamber will have the same effect as when the cylinder-cap gasket leaks. A leak at the drain plug in the pressure chamber will result in the escape of pressure-chamber air and will affect the operation of the equalizing portion in the same manner as a leaky equalizing valve. That is, the leak will have a tendency to cause the equalizing portion of the distributing valve to move to release position.

41. Equalizing-Piston Packing Ring Stuck.—The equalizing-piston packing ring must have spring or flexibility in its groove in the piston in order to be air-tight and still permit the piston to move with minimum friction. If the packing ring *27*, Fig. 2, becomes stuck in its groove, thereby losing its spring, the equalizing piston may not move until a considerable difference exists between pressure-chamber and brake-pipe pressures. The piston and valve then move quickly, and the rapid opening of the ports also causes a quicker movement of the application portion. This disorder is indicated by the quick movement of the brake-cylinder hand on the air gage when making an automatic application. A leaky ring may prevent the brake from being applied by the automatic brake valve when the engine is coupled to the train, whereas the brake will operate properly with the engine alone, the reason being that the brake-pipe pressure is reduced more rapidly in the latter case, thereby neutralizing somewhat the effect of the leak by the ring.

42. To check the tightness of an equalizing-piston packing ring, make a brake-pipe reduction of about 5 pounds with a light engine; this should give a brake-cylinder pressure of about 12 pounds. If less than this pressure is developed, the indication is that a part of the brake-pipe reduction has been neutralized by leakage past the ring.

43. Another test is to reduce the brake-pipe pressure to 50 pounds by making a 20-pound brake pipe reduction; next reduce the brake-pipe pressure an additional 5 pounds, thus holding the equalizing piston in service position against the graduating stem. If the ring leaks, air from the pressure chamber will pass by it into the brake pipe and the air from the application cylinder will in turn flow back through the service port in the equalizing slide-valve seat to the pressure chamber. This reduction in the application-cylinder pressure below the brake-cylinder pressure will cause a discharge of air from the brake cylinder at its exhaust port. To test both the ring and the cylinder-cap gasket, place and leave the brake valve in emergency position. If both the ring and the gasket leak, a continuous blow will occur at the emergency exhaust of the brake valve.

44. **Exhaust Valve Leaking.**—A leaky exhaust valve *16*, Fig. 2, will cause a blow at the brake-cylinder exhaust port only when the brake is applied. The leak does not cause a reduction in brake-cylinder pressure, as it is equivalent to a brake-cylinder leak and is automatically kept supplied by the pressure-maintaining feature of the distributing valve.

45. **Equalizing-Piston Graduating Spring Broken.**—A weak or broken graduating spring with a plain cylinder cap is indicated if the brake-cylinder hand of the air gauge moves up quickly to 65 pounds during a service brake application.

FAILURE OF BRAKE TO OPERATE PROPERLY

46. **Brake Not Applying With Automatic Brake Valve.** Reference will be made to the charts when considering a failure of the brake to operate properly, because the color scheme of pressures serves to identify readily the points at which leakage may occur.

When considering such a failure, it must always be remembered that the brake can be applied only by admitting air to the application cylinder, and released by exhausting the air therefrom.

Failure of the locomotive brake to apply when the automatic brake valve is used (see Chart No. 4) may be due to any of the following causes: The double-heading cock in the brake pipe, the cut-out cock in the main-reservoir supply pipe or in the brake-cylinder pipe closed, excessive friction in the application portion, or this portion frozen up, the packing leather and the ring on the application piston leaking, leakage from the application chamber through the drain plug, the application-cylinder pipe or the cylinder-cover gasket leaking, the pressure chamber not charged or leaking, excessive friction in the equalizing portion, a badly worn ring on the equalizing piston, or a cut or worn bushing, the safety valve leaking or its spring having no tension.

47. **Brake Not Applying With Independent Brake Valve.** If the locomotive brake can be applied with the automatic brake valve and not with the independent brake valve in slow-applica-

tion position, it is evident that the cut-out cock in the main-reservoir supply pipe and in the brake-cylinder pipe are open and that the application portion of the distributing valve is operating properly, hence the cause of the trouble must be looked for elsewhere. The regulating spring of the reducing valve may have no tension, the slow-application port in the rotary valve may be stopped up, the application-cylinder pipe may be obstructed, or the distributing-valve release pipe may leak in excess of the capacity of exhaust port *i*. Placing the brake valve in quick-application position, as shown in Chart No. 10, will apply the brake if the slow-application port is stopped up or if the distributing-valve release pipe is leaking.

48. **Brake Releases After an Automatic Application.**—A failure of the brake to remain applied with the automatic brake valve on lap (see Chart No. 5) is due only to a leak of air from the application cylinder, either at the drain plug, the cylinder-cover gasket, or the application-cylinder pipe. It is assumed that the leakage is not sufficient to prevent the locomotive brake from being applied. The places containing application-cylinder air are colored purple on the chart.

If the brake remains applied on lap but releases in release (see Chart No. 6) or holding position, it is then necessary to look for the leak only in the distributing-valve release pipe, the release pipe, or the safety valve, which is now cut in, as it will be noted that these pipes do not contain pressure in Chart No. 5.

The leak is in the release pipe between the brake valves if placing the independent brake valve in lap position prevents the brake from releasing in full-release or holding position.

49. **Brake Releases After Independent Application.**—The releasing of the brake after an independent application is caused by a leak from the application cylinder or chamber (see Chart No. 11) either at the drain plug, the cylinder-cover gasket, the application-cylinder pipe, the safety valve, or the distributing-valve release pipe.

50. **Brake Applies With Too High a Pressure With Independent Brake Valve.**—If the brake applies with a pressure

exceeding the adjustment of the reducing valve in quick-application position, and not in slow-application position, the reducing valve requires cleaning.

In slow-application position, the reducing valve can supply the air without opening fully, and therefore will usually regulate the pressure properly. In quick-application position, the heavy reduction opens the reducing valve wide, and the supply-valve piston, *being dirty and sticking, delays its closing and results* in an application-cylinder pressure, and therefore a brake-cylinder pressure in excess of the adjustment of the valve.

51. **Brake Not Releasing.**—If the locomotive brake can be released by the automatic brake valve, but will fail to release after an independent application and a return to running position, the trouble is caused by the equalizing slide valve not being in release position, thereby preventing cavity *k* in the valve face (see Chart No. 8) from connecting ports *h* and *i*, and allowing the air to pass from the application cylinder to the distributing-valve release pipe.

The failure of the equalizing slide valve to be in release position is due to an improperly working feed-valve in combination with brake-pipe leaks, or to an overcharged brake pipe. The equalizing piston, and therefore the equalizing slide valve, can be forced back to release position by quickly moving the handle of the automatic brake valve to full-release and back to running position.

If the brake will release promptly with the independent brake valve in release position, but releases slowly with the automatic brake valve in running position, the application portion is in good condition, and the trouble must be due to restricted ports or passages in the equalizing slide-valve seat or in the brake valves, it being assumed that both sections of the release pipe are clear.

The test to locate the trouble would be to disconnect the distributing-valve release pipe at the valve, and then make an application and release. If the release is still slow, the restriction is in the passageways in the distributing valve. A failure of the brake to release after either an automatic or an

independent application may be due to excessive friction in the application portion caused by lack of lubrication or by an accumulation of gum and dirt, or by a leaky packing leather or packing ring on the application piston.

LEAKS

52. Test for Leaks.—Leaks from the application cylinder and its connections may be tested for by placing and leaving the independent brake valve in slow-application position, the distribution of pressure being shown in Chart No. 10. The places at which the air may escape, such as the application-cylinder pipe, the distributing-valve release pipe, the safety valve, the drain plug, and the cylinder-cover gasket, may be tested by placing the hand firmly on the suspected parts or by using a torch. The pipes are liable to wear through and leak where they pass through the floor of the cab and they should be carefully inspected at these points. The release pipe, which does not contain pressure at this time, can be filled with air and tested by placing the automatic brake valve in holding position and then moving the independent brake valve from slow-application to running position. If the brake releases, the release pipe is leaking.

53. Test for Brake-Cylinder Leakage.—To test for brake-cylinder leakage, place the independent brake valve in slow-application position, the distribution of pressure then being the same as shown in Chart No. 10, and leave it there during the entire test. Note the pressure on the brake-cylinder gage. If the cut-out cock in the distributing valve supply pipe is now closed, the total brake-cylinder leakage for 1 minute will be indicated by the fall of pressure as shown on the gage. It is required that the locomotive brake shall remain applied for 5 minutes after a full service application has been made from maximum brake-pipe pressure, and with communication to the brake cylinders closed.

The brake cylinders of the driver, the tender, and the truck can be tested separately by cutting out the other brake cylinders, opening the cock in the supply pipe, and noting the brake-

cylinder pressure developed. The leakage for 1 minute can then be ascertained by closing the cut-out cock in the supply pipe.

A less refined test for brake-cylinder leakage, but one that can be made frequently, is to apply the brake and note the increase in the number of exhausts made by the compressor in maintaining the pressure at standard when holding the brake applied.

LOCOMOTIVE BRAKE CREEPING ON

54. The locomotive brake sometimes applies lightly, or creeps on, with both brake valves in running position. The brake-cylinder pressure developed may be sufficient to cause overheating and loosening of the tires without perceptibly affecting the brake-cylinder gage, as a brake-cylinder pressure of 2 pounds will force the pistons out but it would be difficult to note this pressure on the gage.

The brake applies with the brake valves in running position, not because of any disorder in the distributing valve, but because of an improperly working feed-valve that does not open promptly and supply the brake-pipe leaks. The unsupplied brake-pipe leaks then cause the distributing valve to operate and apply the brake, because they now affect the brake-pipe pressure in the same manner as does a reduction made by the brake valve.

It must not be assumed that because both brake valves are in running position the application of the brake is necessarily prevented; for, as already pointed out in Art. 27, the communication between the application cylinder and the atmosphere can be broken by means of the automatic brake valve, the independent brake valve, or by the equalizing slide valve. The positions of the brake valves can be seen, but the position of the equalizing valve is hidden. However, reference to Chart 4, automatic service position, shows that the connection between ports *h* and *i*, and therefore between the application cylinder and the distributing-valve release pipe, is broken when the valve moves to service position. Therefore, when the equalizing portion of the distributing valve is moved to service

position by the action of the brake-pipe leaks, the air from the pressure chamber cannot then escape through the distributing-valve release pipe to the atmosphere at the automatic brake valve, but passes to the application cylinder and applies the brake.

The brake should be released by a quick movement of the automatic-brake valve handle to full-release and then to running position, thereby causing the equalizing valve to reestablish communication between the application cylinder and the distributing-valve release pipe through ports *h* and *i* and cavity *k*.

The brake should not be released by placing the independent brake valve in release position, as the equalizing portion would be left in lap position (see Chart No. 12). A light reduction of brake-pipe pressure would then move the equalizing piston and graduating valve to service position and reapply the brake.

The brakes on the cars are not affected by an improperly working feed-valve to the same extent as is the brake on the engine, the reason being that the engine brake is generally maintained in better condition than the car brakes.

DISTRIBUTING VALVE VIBRATES

55. When the brake is being applied, the distributing valve will sometimes vibrate to such an extent as to jar the engine. This action is caused by a worn collar *47*, Fig. 2, on the application piston stem or by a worn bushing.

When the pressure in the application cylinder has caused the application piston to move to the right and open the application valve, the pressure behind the piston increases so rapidly on account of the worn collar that it forces the piston back to the left. As the pressure in the application cylinder is gradually increasing when the brake is being applied, the piston will then move back to the right. This to-and-fro movement of the piston will occur so rapidly as to cause the distributing valve to vibrate, and the rapid movement of the piston may break the exhaust valve.

The remedy for this trouble is to babbitt the collar, and then turn it down to the proper size, and thus prevent the vibration of the application piston.

APPLICATION-CYLINDER PIPE AND DISTRIBUTING-VALVE RELEASE PIPE CROSSED

56. An error is sometimes made when connecting the application-cylinder pipe and the distributing-valve release pipe to the distributing valve, the pipes being crossed; that is, the application-cylinder pipe is connected to the distributing-valve release pipe connection, and the distributing-valve release pipe is connected to the application-cylinder pipe connection.

The operation of the locomotive brake will not be affected by crossing the pipes, with the exception that the brake cannot be released by the independent brake valve after being applied by the automatic brake valve. The failure of the brake to release at this time will be understood by referring to Fig. 3 which shows the pipes crossed, and the brake applied by the automatic brake valve, this brake valve and the distributing valve being shown in lap position.

When the brake is applied by the automatic valve, the air that enters the application cylinder passes to the distributing-valve release pipe, but cannot pass to the application-cylinder pipe because the equalizing valve breaks the connection between the pipe and the application cylinder.

Therefore, placing the independent brake valve in release position as shown merely connects the empty application-cylinder pipe to the atmosphere, and the brake will not release. If it is imperative that the locomotive brake be released at once, close the double-heading cock and place both brake valves in running position. This operation prevents the release of the train brakes, and moves the application portion of the distributing valve to release position. The application cylinder is now connected, through the distributing-valve release pipe, the independent brake valve, and the release pipe, to the emergency exhaust port of the automatic brake valve, thereby exhausting the air from the application cylinder and releasing the brake. The brake valve is then returned to lap position and the double-heading cock opened.

57. If the engine on which the pipes are crossed is the second engine in the train, the brake on this engine cannot be

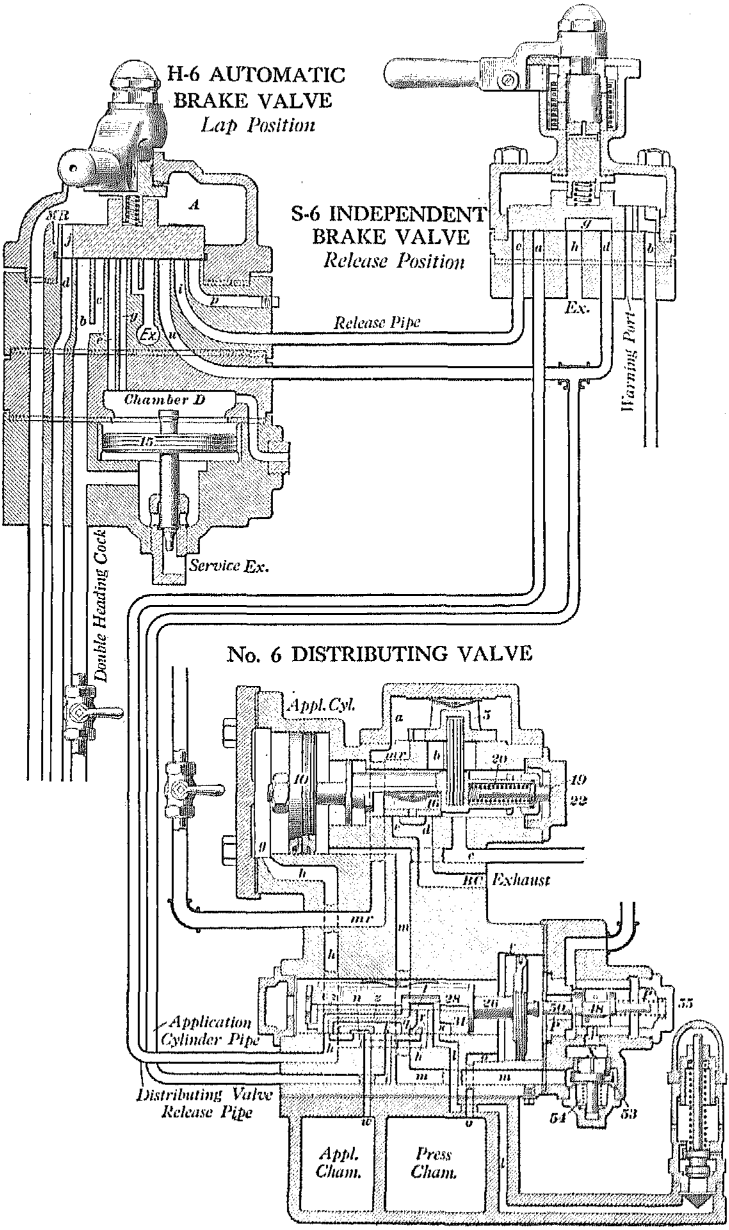

H-6 AUTOMATIC
BRAKE VALVE
Lap Position
S-6 INDEPENDENT
BRAKE VALVE
Release Position
Release Pipe
Ex.
Warning Port
Chamber D
Service Ex.
Double Heading Cock
No. 6 DISTRIBUTING VALVE
Appl. Cyl.
BC Exhaust
Application
Cylinder Pipe
Distributing Valve
Release Pipe
Appl.
Cham.
Press
Cham.

FIG. 3

applied from the leading engine, as the application cylinder is open to the emergency exhaust port through the distributing-valve release pipe.

In order to avoid the possibility of the locomotive leaving the roundhouse tracks with the pipes crossed, in addition to other prescribed tests, the brake should be applied with the automatic brake valve, and then released with the independent brake valve; this can be done only if the pipes are correctly connected.

Another test is to leave both brake valves in running position, and then open the angle cock on the tender. If the brake will not apply, and there is a blow at the emergency exhaust port when the angle cock is open, it indicates that the pipes are crossed.

BROKEN PIPES

58. **Prevention.**—Broken or leaky pipes can largely be prevented if the piping is well clamped and the different valves and their brackets are secured so as to prevent vibration. The brake-cylinder-bracket bolts should be fitted to prevent any movement of the brake cylinders and consequent strain on the attached piping when the brakes are applied. Pipes usually break at the studs of the union connections or at the nipples used to connect the piping to the brake valves, distributing valve, and brake cylinders. A leak due to a slight crack in a stud or nipple is usually the first indication of a defect in these parts. Therefore, all studs and nipples should be regularly inspected for leakage, and promptly repaired, thus avoiding the possibility of a pipe breaking on the road, as a leak generally indicates a defective part that will finally break. Care should also be taken to see that all pipe joints are tight.

59. **Main-Reservoir Supply Pipe Broken.**—If the main-reservoir supply pipe to the distribution valve, Chart No. 1, breaks, the locomotive brake will be inoperative unless repairs can be made, as the break cuts off the supply of main-reservoir air to the distributing valve. While several methods have been suggested whereby a brake on the locomotive could be used

with a broken supply pipe, yet the most practical one is to replace the broken pipe by two signal hose or by two brake-cylinder hose, as the supply pipe and the nipple ends of the hose are both $\frac{3}{4}$ inch. One hose can be screwed into the distributing valve, the broken part being first backed out with a cape chisel, and the other screwed into the cut-out cock or the nipple end of the union, whichever is nearer the distributing valve, and the hose then coupled. If these repairs cannot be made, the cut-out cock in the supply pipe must be closed, and the local rules observed in regard to handling an engine without a brake.

60. Brake-Pipe Branch Pipe Broken.—If the brake-pipe branch pipe, Chart No. 1, to the distributing valve breaks off, it will cause all brakes to apply in emergency, due to the entire loss of brake-pipe air. The connection between the distributing valve and the brake pipe can be made by the air-signal hose, as the branch pipe is a $\frac{3}{4}$-inch pipe. If this cannot be done, plug the pipe toward the brake pipe and operate the locomotive brake with the independent brake valve and the train brakes as usual.

However, the independent brake valve must be placed in release position to release the brake on account of the equalizing portion not being in release position, the exhaust port *i* being therefore blanked.

61. Distributing-Valve Release Pipe Broken.—A broken distributing-valve release pipe does not seriously affect the operation of the locomotive brake with the automatic brake valve, as it merely prevents release and holding positions from holding the brake applied. It is therefore unnecessary to plug the opening at the distributing valve.

Should an independent application be attempted, air will escape at the break, as the equalizing valve has the application-cylinder pipe and the distributing-valve release pipe connected by ports in the valve seat.

If the release pipe breaks, the operation of the locomotive brake by the automatic brake valve will be affected in the same manner as when the distributing-valve release pipe breaks, but

the brake can be operated by the independent brake valve as usual. The locomotive brake can be held applied when releasing the train brakes, by first lapping the independent brake valve.

62. **Application-Cylinder Pipe Broken.**—A broken application-cylinder pipe at the distributing valve, automatic brake valve, or independent brake valve, prevents the locomotive brake from being operated by either brake valve until repairs are made, as air cannot be admitted to or retained in the application cylinder. The pipe must be plugged toward the distributing valve, in which event the brake can be operated by the automatic brake valve, but not by the independent brake valve. The brake can be operated as usual if the branch pipe to the automatic brake valve breaks and is plugged, with the exception that no air can pass to the application cylinder in emergency position. Some roads recommend removing the application-cylinder pipe when it is broken, and substituting the distributing-valve release pipe. The safety valve should be adjusted to 35 pounds so as to prevent damage to the locomotive tires in the event of a break-in-two.

63. **Distributing-Valve Brake-Cylinder Pipe Broken.**—A broken brake-cylinder pipe, Chart No. 1, or the pipe leaking badly causes a loss of main-reservoir air and will be indicated by the falling of the hand of the main-reservoir air gage when a brake application is made; for as soon as the application valve moves to open position the air from the main reservoir will escape to the atmosphere through the broken pipe. The loss of main-reservoir air can be stopped by moving the independent brake valve to release position, thereby causing the application-piston graduating spring to move the application piston and valve to lap position.

If the pipe breaks at the distributing valve, the cut-out cock in the distributing-valve supply pipe must be closed so as to prevent main-reservoir air from entering the distributing valve. The locomotive will then be without a brake. If the pipe should break between the cut-out cock and the brake cylinders, the brake-cylinder cut-out cock should be closed. This cuts

out the driver brake but does not affect the tender brake or the truck brake.

64. **Reducing-Valve Pipe Broken.**—If the reducing-valve pipe breaks off at the independent brake valve, the locomotive brake cannot be applied with this brake valve, but the brake can be operated by the automatic brake valve as usual. The loss of air through the pipe can be prevented by slacking off on the regulating nut until all the tension is removed from the regulating spring in the reducing valve. It is possible that a heavy automatic application might cause the pressure in the application-cylinder pipe to unseat the rotary valve of the independent brake valve, as there is no pressure above it, and thus prevent the brake from applying. This is not probable, and can be tested for by a heavy brake application when standing. If necessary, the unseating of the rotary valve can be prevented by placing the handle of the independent brake valve in slow-application position before beginning an automatic application, thus permitting application-cylinder air to pass to the space above the rotary valve. The independent brake valve must be placed in running position before releasing with the automatic brake valve.

65. **Feed-Valve Pipe Broken.**—A broken feed-valve pipe prevents air from being supplied to the brake pipe in running and holding positions and makes it necessary to use full-release position for this purpose. If the pipe breaks between the feed-valve and the brake valve, the escape of air can be prevented by removing the tension from the regulating spring of the feed-valve. The pipe on the brake-pipe side of the failure must be plugged to prevent the escape of brake-pipe and main-reservoir air.

A uniform brake-pipe pressure can be maintained with the brake valve in full-release position by regulating the main-reservoir pressure carried by the compressor steam valve, as otherwise the pressure would increase to the adjustment of the maximum-pressure head of the governor. With the automatic brake valve in full-release position, the connection between the release pipe and the atmosphere is closed. This prevents the

escape of any air that might leak into the application cylinder, and as a result the locomotive brake would apply. The application of the brake under this condition can be prevented by uncoupling the release pipe at the automatic brake valve.

66. High-Pressure Operating Pipe Broken.—A broken high-pressure operating pipe prevents the high-pressure top of the governor from stopping the compressor in the last three positions of the brake valve. Therefore, in these positions, the compressor must be controlled by the compressor throttle.

67. Low-Pressure Operating Pipe Broken.—If the low-pressure operating pipe breaks, the pipe should be plugged toward the brake valve so as to prevent the escape of air in the first three positions of the brake valve. The maximum-pressure head of the governor will then control the compressor.

68. Equalizing-Reservoir Pipe Breaks.—The instructions on some roads when the equalizing reservoir pipe breaks are to disconnect the pipe at the gage-and-equalizing reservoir tee, apply a blind gasket, and couple up the pipe again, then use the brake valve in service position when making the reduction and stop the discharge of brake-pipe air through the exhaust fitting by closing the double-heading cock. Other roads require the enginemen to carry a water-gage gasket in their equipment, then the pipe, when broken, is disconnected and a blind gasket applied as before and the opening in the brake-pipe exhaust fitting is plugged with a wad of wet paper that is held in place by slipping the gasket over the exhaust fitting. With this method the brake valve is used carefully in emergency position when making service stops. The brake-pipe exhaust fitting with the H-6 brake valve cannot be removed and the opening plugged as with the G-6 brake valves because a wrench cannot be worked between the vertical pipes. If the equalizing reservoir gage pipe should break, the pipe should be disconnected from the tee and a blind gasket inserted as before. The engineer must then be guided by experience in determining the length of time to hold the brake valve in service position for a given reduction of air from the equalizing reservoir.

REPAIRING DISTRIBUTING VALVES

69. **Stripping.**—The first step in the repair of distributing valves is to take off all caps, remove the working parts and mark them so that they can be identified and reapplied to the same body. The working parts are examined and an order placed for any that may be worn so badly that they cannot be used again. Thus the steel application-valve pin may be worn or the hole in which it fits in the application valve or in the application piston may have become enlarged, thus requiring new parts.

The pistons should be placed between lathe centers to determine whether they are straight. The graduating valve is a snug fit in the stem of the equalizing piston and cannot be reapplied if the stem is bent. The application graduating spring should also be examined. The valve bodies and the working parts are then immersed and boiled in a cleaning solution where they should be permitted to remain for 6 hours or more. After being removed from the cleaning solution, the bodies are blown off with steam and it should next be ascertained whether all ports and passages are clear. This is done by blowing air through them; if a good volume of air discharges, it is an indication that the passages are not obstructed. A passage found partly or wholly plugged can be cleaned out by enlarging the small holes previously plugged by the manufacturer to close the ends of the core holes after the body has been cast. The enlarged holes are then tapped for small gas plugs that will be found convenient to clean the passages at other times.

70. **Necessity for Reconditioning Valves and Valve Seats.** If a perfectly flat piece of metal is pressed against another flat piece and moved back and forth over it, the surfaces in contact will wear about the same amount all over. But if holes or ports are drilled in the surfaces the wear will not be uniform; more wear will occur where solid surfaces move against each other than where a solid surface moves over or partly over a port. A low spot will develop on the surface of a valve or its seat where the surfaces are always in contact. The surface will

remain high where the wear is lessened by a full surface moving over a port. Owing to the arrangement of the ports, high and low spots develop on the valves and valve seats of the distributing valve, preventing these parts from making intimate contact and resulting in leaks.

The work of reconditioning a valve and its seat falls under three heads, namely, filing, scraping and spotting, and grinding in, these operations being performed in the order named. Filing removes the high spots and also takes off as much more of the surfaces as will enable them to true up. Scraping removes any slight high spots that may be left after the filing operation, especially if a narrow file has been used, but if perfect filing were possible, scraping would be unnecessary. With a file especially adapted to this work, very little scraping will be required. Spotting is a test made at intervale during scraping to locate the high spots and to indicate when further scraping is unnecessary. Grinding in is the final operation and is employed to smooth off the somewhat roughened surfaces due to filing and scraping and thus bring them into intimate contact.

71. **Filing.**—The principal work involved in the repair of distributing valves is the renewal or reconditioning of the surfaces of the valves and the valve seats. The way in which this work is done will be outlined, but it is only by practice and experience that one can become proficient in doing it. The seat of the application valve is of cast iron and will generally be found in somewhat worse condition than the other seats, which are of brass. This seat as well as the seats on which the equalizing valve and the exhaust valve wear can be most satisfactorily renewed by using very fine parallel files made especially for this work and of the same width as the seat. Such a file may be considered as a face plate with fine cutting teeth incorporated in it. Although the ordinary types of file can be employed, yet their use requires more scraping and grinding in to recondition the parts.

Each time a seat is reconditioned it will, of course, be lower than the previous seat but the reconditioned seat should always

be parallel with the original one. This condition is difficult to obtain with a file, but the filing should be done with this aim in view. The valve never travels the full length of its seat, so that there will be a high area at each end and these high points should be used as a guide, that is, each stroke of the file should be made to take approximately the same amount off each point by applying the same pressure at the ends. The file should be held flat and worked lightly and it positively must not be rocked on its seat. When the lowest point on the seat has been reached as shown by the file cutting, the filing should be discontinued and the seat tested with a face plate, especially if a narrow file has been used. If the filing has been well done, the area in contact with the face plate will be found to be considerable. With the filing well done, very little scraping will be necessary.

72. The face of the application valve is treated in the same manner, except that the file can be placed in a vise or on a flat surface and the valve rubbed back and forth on it. The valve can be held flatter on the file than the file can be held on the valve, the result being a better seat.

The exhaust valve and its seat, the equalizing valve and its seat, and also the graduating valve are reconditioned in the same manner. The same kind of file of the proper width is used, but as the file must be passed through the bushing and can only be supported at the ends, the filing operation is more difficult. The valves are preferably filed by placing the file in a vise as already explained. One side of the exhaust valve should be marked to insure its proper application because the valve will not be air-tight if it is ground in one way and applied the other way.

73. Scraping and Spotting.—The spotting plate used must be accurate. Its surface is rubbed free of oil and foreign matter and polished lightly with a cloth, and a very thin smear of lampblack, red lead or other substance is applied on its surface. A thick coating must not be applied because it destroys the accuracy of the spotting plate. When rubbed on the seat, the lampblack will be transferred to the high spots on the seat, thus locating them. Hence all the surfaces that are found

smudged with lampblack must be scraped down, and this is done by a fine sharp scraper that must be used in such a manner that the seat will not be gouged. The proper progress of the work can be judged best by applying the plate at frequent intervals. With the scraping done properly, the area of the high spots that is accumulating the lampblack will be found to increase with each application of the spotting plate, thus showing that the high spots are being gradually worked down. However, the fact that a high spot disappears entirely may mean that the spot has been scraped too deep, and this will require much more work to perfect the seat. One cannot expect to be able to make a bearing over the entire seat but a good workman should be able to cover at least 75 per cent of the area with lampblack before the spotting is discontinued, and at the same time he should be sure that there are no bad places that cannot be taken out by a small amount of grinding. The aim is not to eliminate the black on the valve seat but rather to have it spread evenly over the entire surface. This can be accomplished only by easing off the high points.

It is more difficult, owing to their location, to scrape and spot the equalizing slide-valve seat and the exhaust-valve seat. If the filing has been well done, it is possible to do a fairly satisfactory job by omitting the scraping and spotting operation and merely grinding in the valves which have been previously scraped to a good seat.

74. Grinding In.—The valves and their seats having been reconditioned, the next step is to grind them in. Valves and seats that have been well spotted in will require but little grinding; in fact, the less grinding that is done the better. The reason is that grinding is a duplication of the wear that occurs in service, and, as already pointed out, owing to the presence of the ports, high and low spots will develop if the grinding is continued too long. In fact, the longer the grinding is continued the worse the surfaces will become, although to the eye they may look better. The aim should be to spot the valves in well and do the minimum of grinding, thereby lessening the amount of work and insuring tighter valves .

75. The actual work of grinding in is done with a very fine grade of carborundum paste or, if desired, no grinding compound whatever may be employed, the surfaces being merely rubbed together with oil for finishing. The face of the valve is coated and rubbed lightly back and forth on its seat with very little pressure or with little more pressure than its own weight. With a seat in the interior of a bush, the valve can be most conveniently moved by a stick. A simple test to determine the accuracy of the work is to draw lines on the face of the valve and its seat with a soft pencil and then rub the valve lightly on its seat again. If the pencil marks are now all blotted out on both the valve and its seat, the job is a good one; if not, the grinding in should be continued. A pencil mark that remains of course indicates a low spot.

It is very important that the pencil marks between two adjacent ports rub out completely, otherwise the air will leak from one port to the other. This is particularly true of the graduating-valve seat, where the two large ports are close together. Under service conditions, the valve always wears a slight hollow between these ports.

76. Some air-brake men believe that many distributing valves should not be repaired oftener than when absolutely necessary. A valve in good condition found, for any reason, in the back shop may in many cases be put in excellent shape by merely cleaning it. This implies the removal of the old lubricant that may have congealed, and also any foreign matter. The valve is stripped and wiped out, the parts are worked back and forth, and new lubricant is applied. The slide valves and their seats can often be cleaned up by grinding them in without using any grinding compound. Many valves so cleaned will be found to pass the test without any further repairs. However, the foregoing should not be taken to mean that valves actually in need of repairs may be reconditioned by merely cleaning them.

77. Bushings.—When any of the bushings in the distributing valve are found to be so badly worn as to require renewal, they are ordinarily sent to the manufacturer to have this work done. The work of truing piston bushings is done on a specially

designed machine, made expressly for this purpose, the grinding being done by means of an emery wheel. The bushings have a comparatively long life and may last for 10 to 15 years, so that it costs less to have the manufacturer do this work, than for a railroad to incur the expense of a special machine. Hence, the bushings are ordinarily examined and rubbed with very fine emery cloth to remove any dirt or corrosion that may be found on their surfaces and to polish them so that the piston and the ring will move back and forth with the least friction. The greatest wear on the equalizing-piston bush will be found between service and service-lap positions. It requires workmanship of a high order to fit properly a piston ring to a cylinder that is worn somewhat out of round.

78. **Fitting the Ring.**—The piston packing ring provides the piston with a flexible rim which, by expanding or springing outward against its bushing, prevents leakage from one side of the piston to the other. When a new ring is to be applied to the equalizing piston or to the application piston one should be selected of the proper width to enter the groove with little or no fitting. The ring must not be too loose; it should be capable of being moved in the groove without any side play. After a ring of the proper width has been selected, it is compressed with the ends overlapping and inserted into the bushing in its normal position. Regardless of whether the bushing is perfectly circular or not, a new ring will not fit it all the way around because the ring was cut from stock of a slightly larger diameter than the bushing in order for it to have the required spring. The ends of the ring are now carefully filed until it will expand outward against the bushing sufficiently for the ends to interlock.

The ring can be made to conform to the shape of the bushing, and hence made air-tight as nearly as possible, in either one of two ways. One way is to peen around the ring with a small soft-faced hammer, tapping the inner circumference lightly all the way around. This expands the ring and relieves the bushing from the excessive outward thrust of the ring at the joint. The other and longer way is to wear the ring into the

bushing by placing it on a special wearing piston that permits the ring to be pulled to and fro in the bushing, which is well-oiled to prevent it from becoming scored. With both of these operations, a slight gap will finally appear between the ends of the ring but, with a bushing that is not wholly circular, this cannot be avoided.

79. The ring is next applied to its piston by inserting one end in the groove and then working the ring in gradually all the way around. If the ring is found to fit the groove rather tightly, a file must not be used under any circumstances. A good method is to rub the sides of the ring on fine emery cloth attached to a perfectly flat surface, the ring being tested frequently in the groove. An old ring that is found to have a gap of $\frac{1}{16}$ inch between the ends when applied to the bushing is discarded.

The fit of the equalizing piston ring should be such that the piston with the equalizing valve, graduating valve, and springs in place can be moved back and forth when grasped by its stem. Then if the port *o* in the back of the flange is closed by the thumb, it should not be possible to pull the piston outwards from its inner position or push it backward from its outer position. If this test fails, it is useless to put the valve on the test rack.

80. The packing ring and the leather are removed from the application piston, and a new ring, provided the gap in the old ring exceeds $\frac{1}{16}$ inch, is fitted to the bushing and applied to the piston in the same manner as already explained. The packing leather is always renewed and the wire expander ring is opened up to give it greater tension before it is reapplied to the piston. When the application piston and valve is reapplied it should be capable of being moved back and forth with the fingers. A fine tool or stick should be used to guide the exhaust valve to its seat so as to avoid damage to the valve or its seat during application. With the piston stem back against the cap, the spring should return the application valve to lap position or $\frac{1}{16}$ inch beyond line and line.

81. Reconditioning of Brake Valves.—The reconditioning of the brake valves does not differ materially from that of the distributing valves. The same care is taken in filing and scraping the rotary-valve seat and the face of the rotary valve, and the two are ground in by rotating one on the other. As already stated, the scraping and spotting should be such that only a small amount of grinding will be necessary, because when the grinding is continued beyond a certain point, the condition of the surfaces will become worse. This is especially true of the narrow bridges between adjacent cavities. The same precaution must be taken in fitting the ring on the equalizing piston as with the distributing valve, and the piston must be capable of a free movement. The end of the piston stem known as the equalizing discharge valve, and its seat, should be trued up and finally ground in with a minimum of grinding. It should be remembered, when making repairs to the equalizing discharge valve, that the tapered and parallel portions of the valve act as a choke to restrict the volume of air discharged through the exhaust fitting. Any change in the size or the taper of this part should be kept at a minimum so that the proper functioning of the valve will be maintained.

It should be seen that all of the ports are unobstructed; any found partly closed should be cleaned out without enlarging them and new gaskets should be applied with the openings to correspond with the ports. The proper lubricant should then be applied to the moving parts before assembly. The valve is then ready to be tested.

AIR SIGNAL SYSTEM

DESCRIPTION

82. Purpose.—The purpose of the air signal system is to permit, by means of a code of whistles, of communication between the cars and the locomotive of passenger trains. A certain number of blasts of the signal whistle conveys certain information to the enginemen; thus, two blasts of the whistle when the train is running means *stop at once*, four blasts when the train is standing means *apply or release the air brakes*, etc.

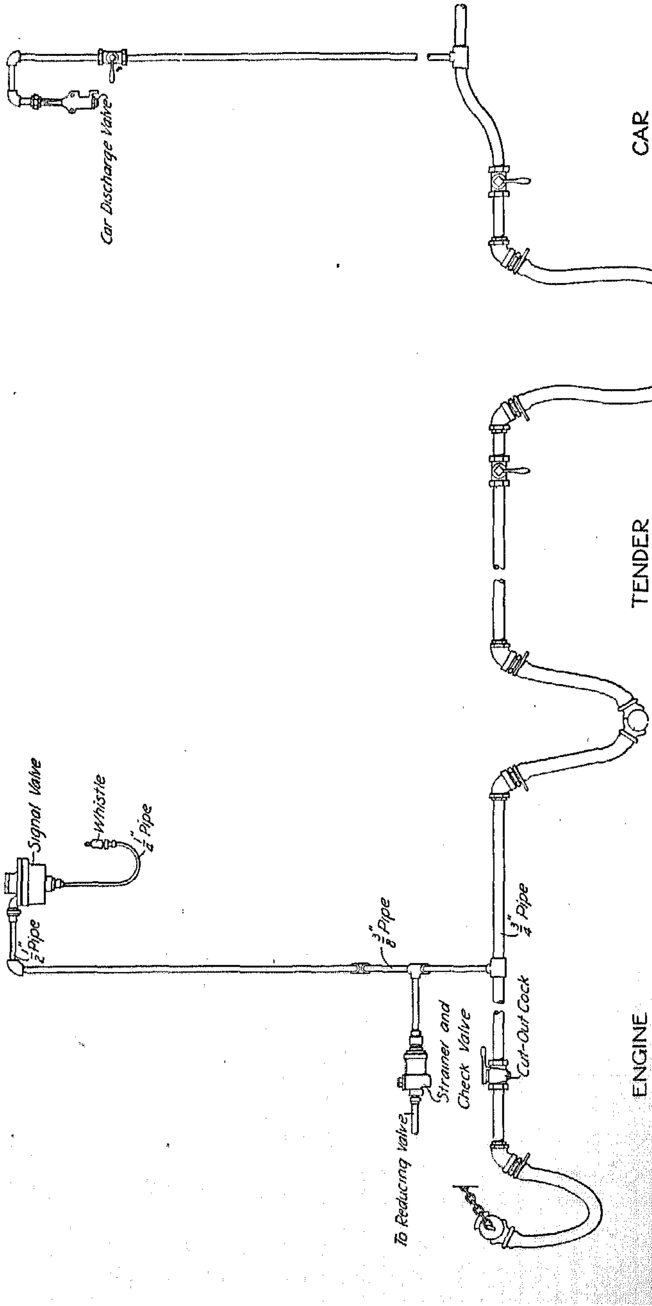

Car Discharge Valve
CAR
TENDER
ENGINE
Signal Valve
Whistle
1/4" Pipe
1/2" Pipe
3/8" Pipe
3/4" Pipe
Strainer and Check Valve
Cut-Out Cock
To Reducing Valve

Fig. 4

The signal valve of the air signal system is operated by pulling the signal cord in a car. This action opens the car discharge valve and reduces the pressure in the signal pipe, thereby causing the whistle to blow. The complete whistle code is given in the book of rules.

83. **Arrangement.**—The air signal system on the locomotive, Fig. 4, consists of a pipe leading from the reducing valve to a combined strainer and check-valve and from it to the signal pipe, which extends the length of the locomotive and tender as does the brake pipe, with the necessary cut-out cocks, angle fittings, hose and couplings, etc., and also a signal valve and a whistle. On a car, the signal system comprises a similar line of piping and hose, etc., and a vertical branch pipe in which a cut-out cock and a car discharge valve are installed. The cut-out cocks in the signal line on either side of the signal hose are open when the handles are at right angles to the pipe; the same is true of the cut-out cock below the car discharge valve.

The strainer in the combined strainer and check-valve protects the check-valve and the signal system from foreign matter. The check-valve prevents a back flow of air from the signal pipe to the reducing-valve pipe as when applying the brake with the independent brake valve. A choke in the combined strainer and check-valve prevents the reducing valve, when transmitting signals, from raising the signal-pipe pressure so quickly as to interfere with the proper operation of the signal valve.

The reducing valve is set for 45 pounds, but as the check-valve spring has a value of 3 pounds, the pressure in the signal line is 42 pounds.

84. **Car Discharge Valve.**—The car discharge valve with the body sectioned is shown in Fig. 5. When the signal cord is pulled, the operating lever *5* moves either to the right or to the left, depending on the direction in which the lever is moved, and fulcrums on one of the pins *6*, thereby forcing the valve *3* from its seat. The air from the signal line that enters the valve at *a* escapes at *b* until the cord is released, then the valve is seated by the spring *4* and the air pressure.

85. Signal Valve.—The signal valve, Fig. 6, consists of a diaphragm case, with a cap and a lower cap nut *7*. The diaphragm *12* separates the case into two portions and supports a plate and a valve stem *10*. A teat on the end of the valve stem serves to open and close passage *e*, which leads to the whistle. The portion of the valve stem immediately above the circular groove *f* fits its bushing *9* snugly. Below the groove the stem is milled triangular similar to *x*. This triangular milling allows the air to pass freely and yet permits the stem to be guided properly to its seat.

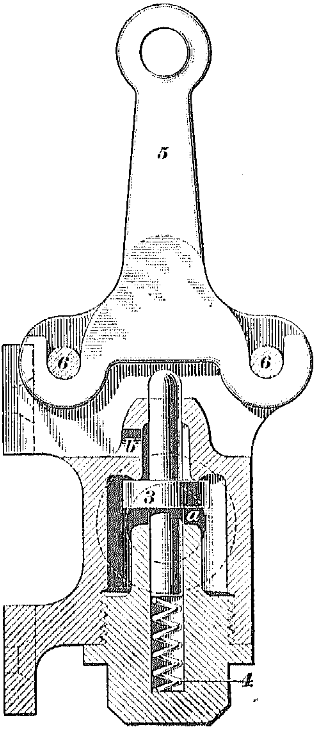


FIG. 5

Air from the signal pipe enters the signal valve at *X* and passes through port *d* into chamber *A*. The air also passes through port *c* and by the valve stem into chamber *B*.

When the car discharge valve is opened a reduction is made in signal-pipe pressure, and since the air is exhausted more rapidly than it is being supplied through the choke in the combined strainer and check-valve, the reduction is felt at the signal valve on the locomotive.

The pressure in chamber *A* can reduce faster than the pressure in chamber *B* can reduce by the rather close-fitting valve stem. As a result, the diaphragm is forced upward, unseating the valve stem, and permitting air to escape from chamber *B* and the signal pipe to the whistle, thereby causing it to blow. When the car discharge valve is closed, the pressures in chambers *A* and *B* balance quickly. The teat on the end of the valve stem is then returned to its seat and thereby causes the whistle to stop blowing.

86. To obtain the best results when transmitting signals, the signal cord should be pulled firmly and quickly, and the discharge valve should be held open fully for one second for each blast of the signal whistle. The discharge valve should be allowed to remain closed for about 3 seconds between discharges so as to permit the pressures in the chambers of the signal valve to equalize. With trains of over twelve cars, 4 seconds should be allowed between discharges.

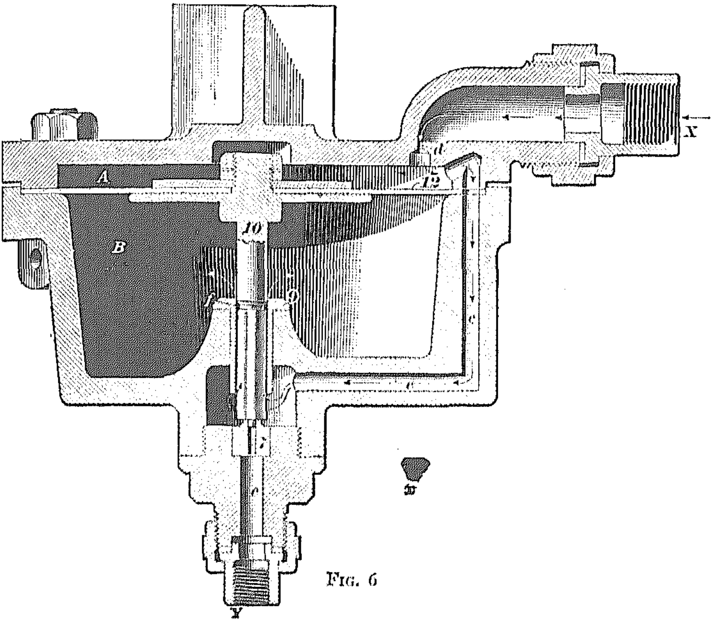


FIG. 6

DISORDERS OF SIGNAL VALVES

87. **Intermittent or Constant Low Whistling Sound.**—This disorder is due to the valve stem making an irregular seat in the lower cap nut.

88. **Undesired Short Blasts.**—This disorder is caused by a dirty and an erratic-working reducing valve in combination with excessive signal-pipe leakage.

89. **False Signaling.**—False signaling, when the locomotive passes over frogs or crossovers or when the engine vibrates,

is due to any of the following: An irregular seat of the stem in the lower cap nut, too loose a fit between the teat on the end of the valve stem and its seat, or too short a teat or none at all.

90. **Double Whistling.**—Double whistling for one opening of the car discharge valve is due to any of the following causes: A stiff diaphragm, the valve stem fitting loosely in its bushing, too loose a fit between the teat and its seat, or a too quick and sharp pull of the signal cord.

91. **Alternate Opening and Closing of Signal Valve.**—The alternate opening and closing of the signal valve for one long continuous opening of the car discharge valve is due to the valve stem being too loose in its bush, or to the teat fitting too loose or being too short.

92. **One Long Blast.**—One long blast instead of several short ones for several short openings of the car discharge valve may be due to excessive friction between the valve stem and its bush, the valve stem may be too short, the teat may be too short or too loose-fitting, the fit between the upper seat of the valve stem and the bush may be too tight, or the reducing valve may be working on a large range.

93. **Whistle Blows When Applying Independent Brake.** This disorder is caused by the leaking of the valve in the combined strainer and check-valve. Such a leak causes the pressure to reduce in the signal line when the brake is applied with the independent brake valve.

TYPE C LOCOMOTIVE SIGNAL VALVE

94. ***Description.***—The type C signal valve is designed to give whistle blasts of the same duration on both short and long trains, a feature not always obtainable with the type of valve previously used.

An exterior view of the valve is given in Fig. 7 and a sectional view in Fig. 8. It consists of three portions; a volume chamber *a* of pressed steel, a top cover *b*, also of pressed steel, and a center casting *c* of aluminum. The three portions are divided into three separate pressure chambers by the dia-

phragms *d* and *e*, these being bound together by the two screws shown. The upper chamber of the valve is connected directly to the signal pipe, the middle chamber charges through the choke *f*, and the bottom chamber charges through the choke *g*. When fully charged, the pressures in all chambers are equal.

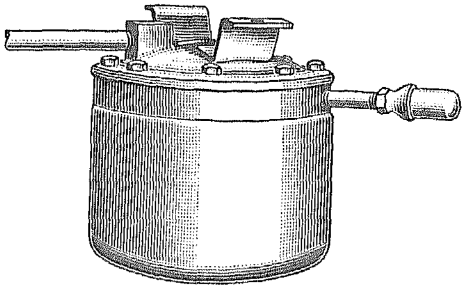


FIG. 7

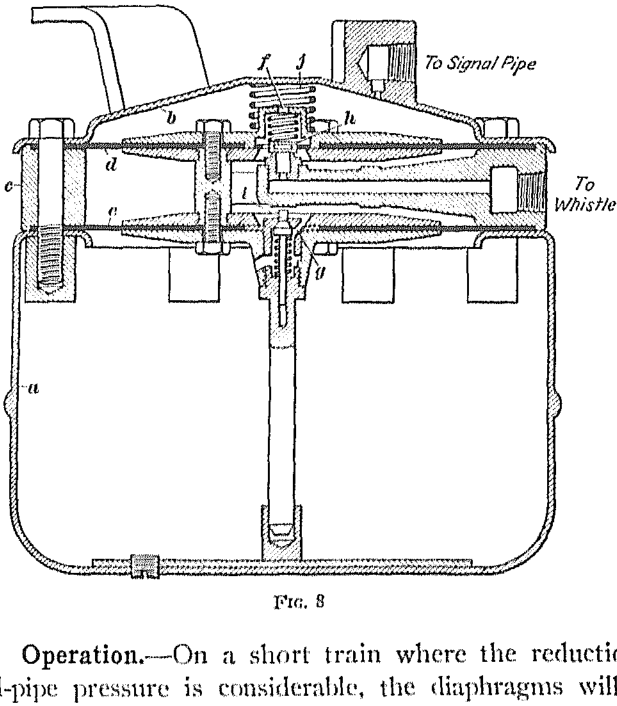


FIG. 8

95. Operation.—On a short train where the reduction in signal-pipe pressure is considerable, the diaphragms will rise higher than on a long train, but this will not cause a longer blast

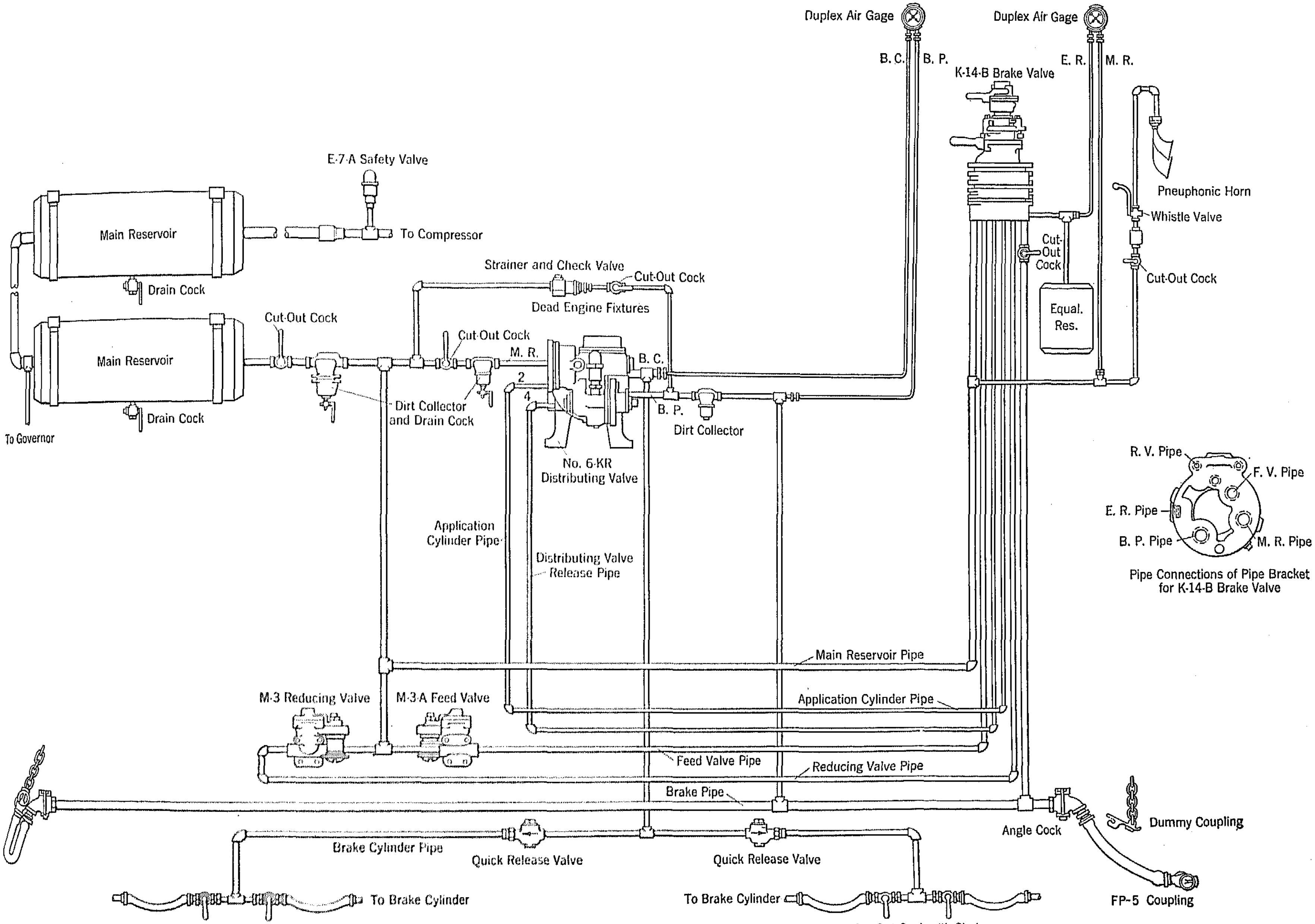
of the signal whistle. When the upper diaphragm rises, valve *h* unseats and permits the air in the middle compartment to pass to the signal whistle. But the greater lift of the lower diaphragm brings the top of the valve *i* against the part above it with more pressure, and hence unseats the valve to a greater extent than otherwise. The valve, when unseated, closes the choke *g*. The pressures in the middle and bottom compartments equalize quickly, thereby causing the valve *h* to seat after a short whistle blast. On a long train the reduction in signal-pipe pressure with the discharge valve held open the same length of time may be only half as much as on a short train, so that the valves *h* and *i* will only be open about half as much as before. If the valve *i* is opened fully to balance a full reduction in a certain period of time, it is only necessary for it to be open half-way to balance half the reduction in the same period of time. Therefore, regardless of the length of the train, the interval between the opening and closing of the valves is the same for a given opening of the discharge valve so that the same short whistle blast is produced in each case.

The diaphragm movement is stabilized by the spring *j*, which prevents false signals arising from signal-pipe leakage.

NO. 14 EL BRAKE EQUIPMENT

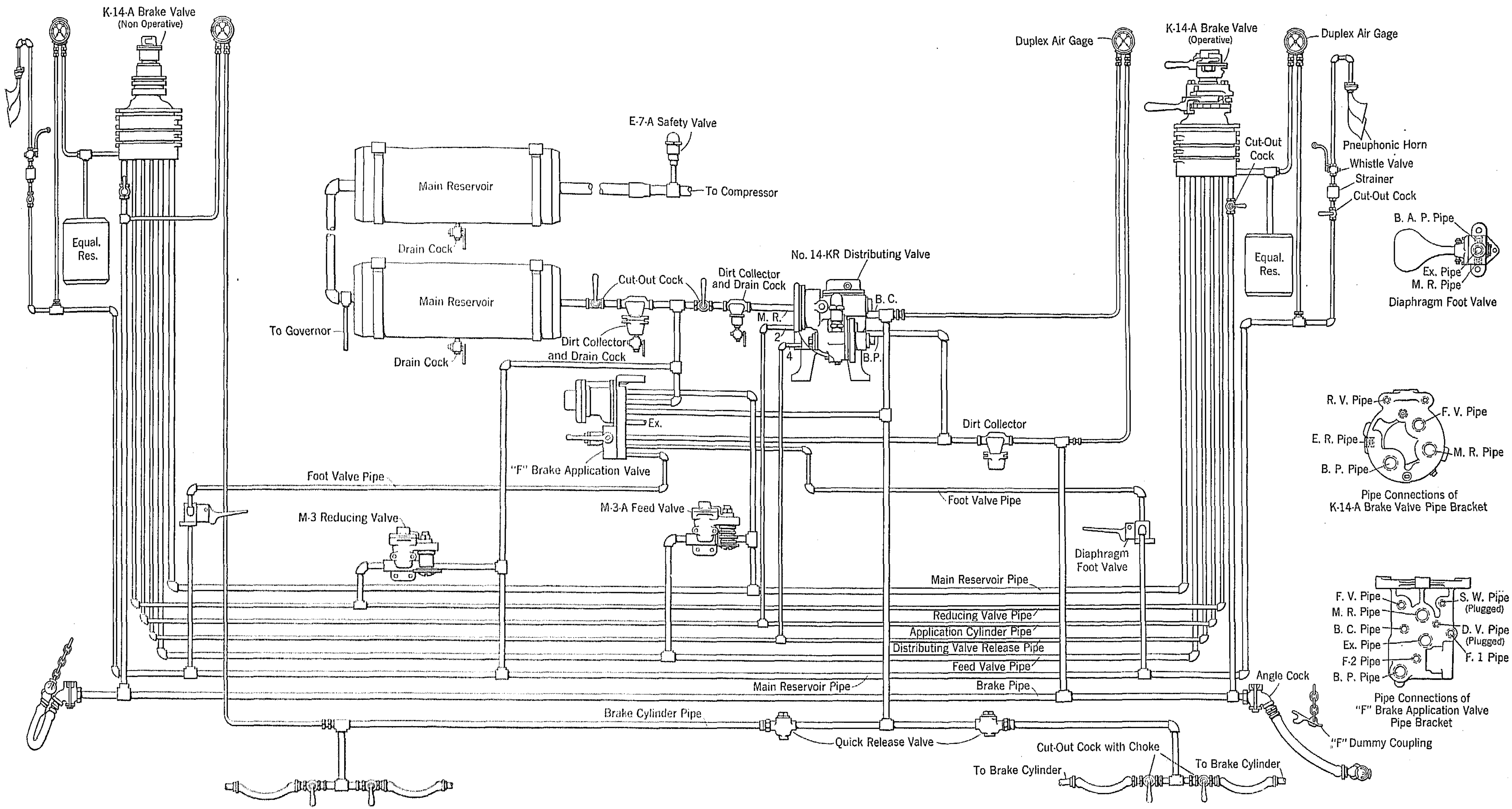
DESCRIPTION AND OPERATION

96. General Description.—The No. 14 EL brake equipment resembles the No. 6 ET locomotive brake equipment so closely in the arrangement and operation of its parts that an extended description is unnecessary. This equipment was designed for Diesel-electric switching locomotives and may be either of the single-end type as shown in the piping diagram, Fig. 9, or of the double-end type as shown in Fig. 10. With the latter equipment, a safety-control feautre is employed which requires a brake application valve and a diaphragm foot valve. A K-14-B brake valve is used with the single-end equipment and a K-14-A valve with the double-end equipment. These brake valves are the same as the H-6 and S-6 brake valves of the No. 6 ET equipment except that they are com-



BB 515D 5548B

Fig. 9



BB 515D 5548B

Fig. 10

bined in one structure. The brake valve positions are the same and give the same brake action as those of the H-6 and S-6 brake valves. A No. 6 KR distributing valve is used with the single-end equipment and a No. 14 KR distributing valve with the double-end equipment.

97. **Compensating Ports.**—The K-14-A brake valve and the 14-KR distributing valve as used on the double-end equipment are each supplied with a compensating port. These ports are unnecessary with the single-end equipment because of the shorter piping between the brake valve and the distributing valve. These ports are used to overcome the effect of the volume of the long distributing-valve release pipe and the application cylinder pipe on the operation of the brakes.

The compensating port in the rotary valve of the K-14-A brake valve supplies main-reservoir air to the application cylinder pipe in automatic service position and to the brake pipe in release position. The air admitted to the long application cylinder pipe offsets the effect of this pipe to increase the volume of the application cylinder and hence decrease the pressure obtained in the brake cylinders for any given brake-pipe reduction. The compensating ports in the distributing valve permit the flow of brake-pipe air to the distributing-valve release pipe during an automatic service application. This action not only serves as a quick-service feature but also prevents any drop in application cylinder pressure and therefore in brake-cylinder pressure when the handle of the automatic brake valve is returned to holding position after an automatic service application. Both types of distributing valves have a duplex poppet-type application valve instead of the slide-valve type used with the No. 6E distributing valve. With the exception of the foregoing, the distributing valves used with the No. 14 EL equipment operate in exactly the same manner as the No. 6-E valve used with the No. 6 ET equipment.

98. **Details Considered.**—The description of the No. 14 EL equipment that follows will be confined to the details in which it differs from the No. 6-ET equipment, namely, the applica-

tion portion of the distributing valve and the safety-control feature.

99. Poppet-Type Application Valve.—The following explains the duplex poppet type of application valve used with these distributing valves:

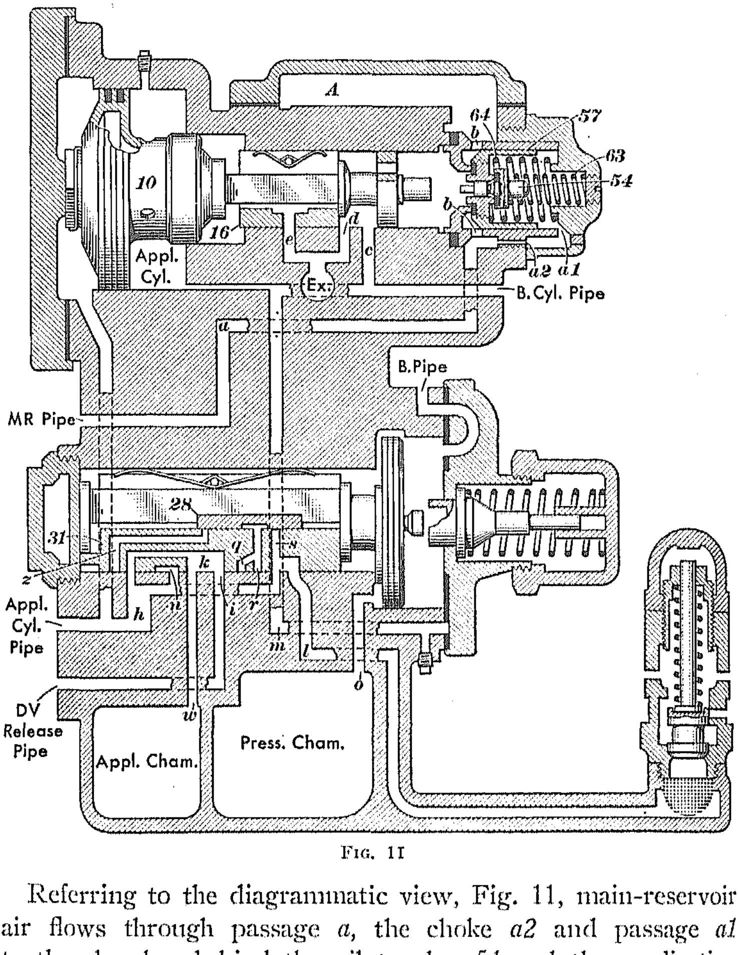
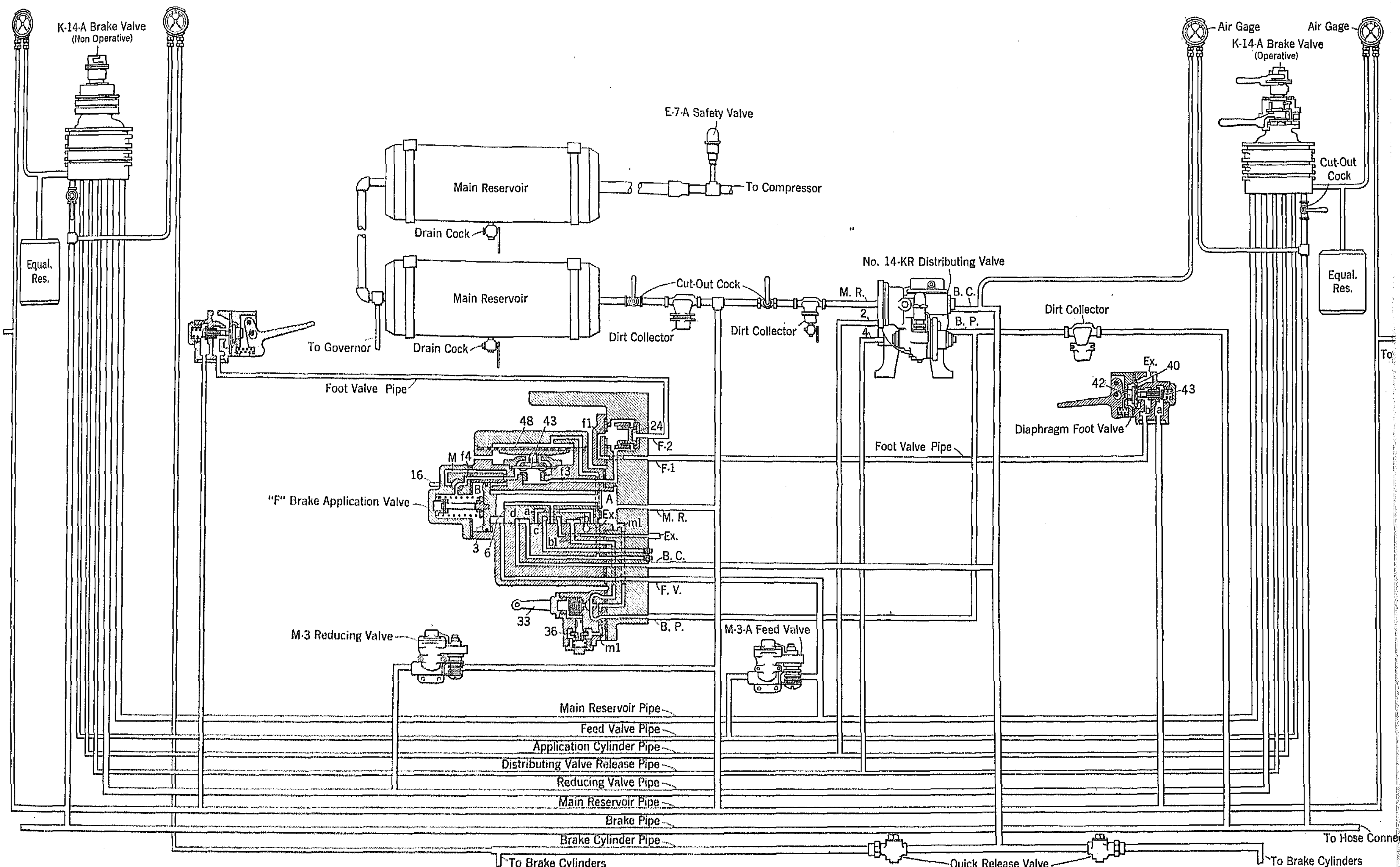


FIG. 11

Referring to the diagrammatic view, Fig. 11, main-reservoir air flows through passage *a*, the choke *a2* and passage *a1* to the chamber behind the pilot valve *54* and the application valve *57*. Main-reservoir air also passes through passage *b* to the face of the application valve *57* and to chamber A.



BB 515D 5548B

Fig. 12

When the brake is being applied, the end of the application piston *10* first engages and unseats the pilot valve *54*, and permits main-reservoir air in the spring chamber to pass to the brake cylinders. The pressure in this chamber then drops quickly owing to the passage of air to the chamber being restricted by the choke *a2*. Then the main-reservoir pressure

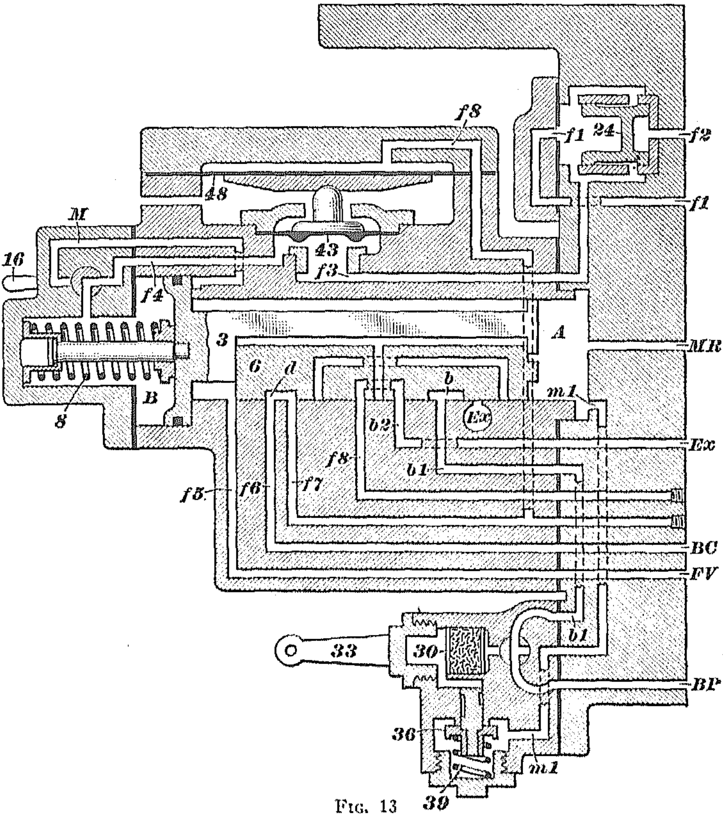


Fig. 13

in passage *b* and in chamber *A* acting over the outer area of the application valve *57* partially overcomes the tension of the springs *63* and *64* and the reduced air pressure in the spring chamber. Therefore, the application valve opens with a small difference in pressures on the application piston *10*. The springs *63* and *64* close the pilot valve and the application valve

promptly when the application piston moves to lap after the required brake-cylinder pressure is obtained. The references shown in Fig. 11 other than mentioned correspond to those of the No. 6 E distributing valve.

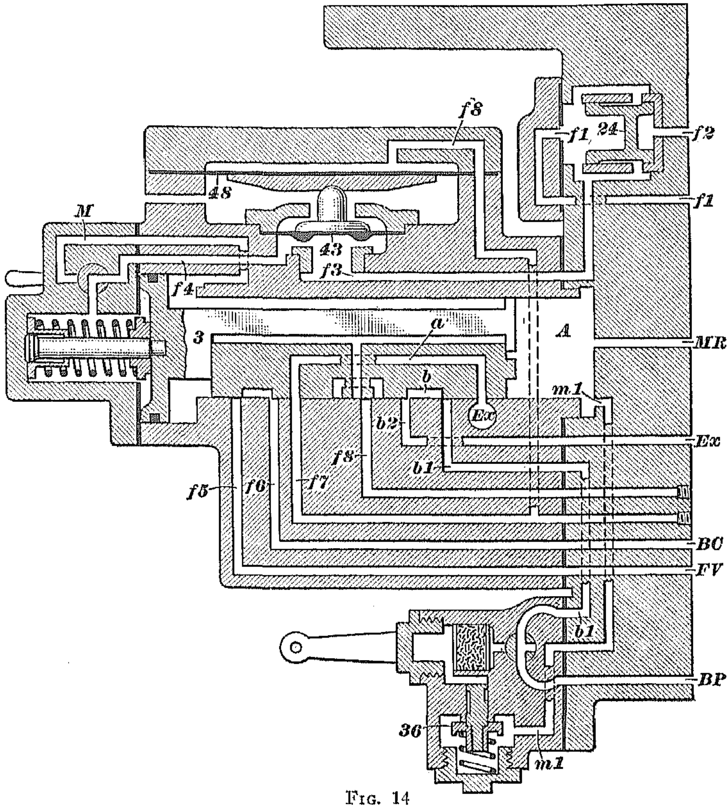


Fig. 14

100. Safety-Control Feature.—A diagrammatic view of the safety-control feature is shown in Fig. 12, an enlarged view of the type "F" brake application valve is given in Figs. 13 and 14, and a view of the diaphragm foot valve is shown in Fig. 15. The purpose of the safety-control feature is to cause, in the absence of a predetermined brake-cylinder pressure, an emergency application of the brakes unless the foot-valve pedal is held depressed. Then should the engineman become incapaci-

tated, the train will be brought to a stop. With the foot-valve pedal held down, Fig. 15, the diaphragm *40* unseats valve *43*, permitting main-reservoir air in chamber *a* behind this valve to pass by it and flow through connection *f1* to the foot-valve pipe and through passage *f1*, Fig. 13, to the brake application valve. At this valve, the air forces the double check-valve *24* to the right, thereby closing off the foot valve on the non-operating end through passage *f2* and next flowing through passage *f3* to the under side of diaphragm valve *43*, which unseats and permits the air to flow through passage *f4* to chamber *B* on the left side of the application piston *3*. With main-reservoir pressure always present in chamber *A* from passage *MR* on the

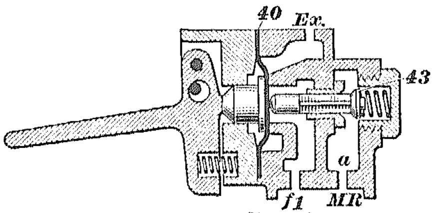


Fig. 15

right side of the piston, spring *8* will move the piston and its slide valve *6* to the right to release position. Main-reservoir pressure is now connected through passage *f5* at the end of the slide valve *6* and passage *FV* to the M-3-A feed valve. The brake cylinders are connected through passage *f6*, cavity *d* in the slide valve *6* to passages *f7* and *f8* that lead to the chamber above the cut-off diaphragm *48*.

101. Should the pressure on the foot-valve pedal be released, Fig. 15, valve *43* will be closed by its spring and the air in chamber *B* of the brake application valve will escape through passages *f4*, *f3*, *f1*, and the foot-valve pipe to the foot-valve exhaust. The main-reservoir pressure in chamber *A* will now force the application piston *3* and its slide valve *6* to the left to application position. In this position, Fig. 14, the air supply from the main reservoir through passage *f5* to the feed valve is cut off by the slide valve *6*, thereby preventing any flow to the brake pipe, and brake-pipe pressure will flow through

passage *b1,* cavity *b,* and passage *b2* to the exhaust *Ex.* on the side of the valve, the ports being of a sufficient size to cause an emergency application. The slide valve *6* cuts off the flow of brake-cylinder pressure through passage *f6* to the chamber above the diaphragm *48,* and this chamber is connected through passages *f8,* and *f7* and cavity *a* in the slide valve *6* to the exhaust port *Ex.* The cut-off valve *43* will then remain open and make it possible to admit air to chamber *B* and release the brakes.

102. The safety-control feature will not function when the brake has been applied and there is a predetermined pressure in the brake cylinders. Brake-cylinder pressure will then build up through passage *f6,* Fig. 13, of the brake application valve,

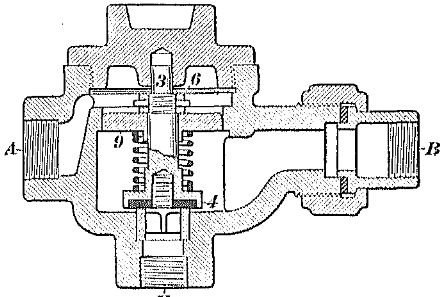


Fig. 16

cavity *d* in the slide valve, and passages *f7* and *f8* to the chamber above the diaphragm *48* and seat the diaphragm cut-off valve *43.* This prevents the escape of air from chamber *B* through passage *f4* to the foot-valve pipe and the exhaust port in the diaphragm foot valve should the foot-valve pedal be released. The safety-control feature can be cut out by closing cock *16,* which breaks the connection between chamber *B* and the foot-valve pipe by way of passages *f4, f3,* and *f1.*

The dead-engine fixtures are incorporated in the brake application valve and comprise a cut-out cock *33,* a strainer *30,* and a check-valve *36,* Fig. 13. With the cock open, brake-pipe air will pass through the strainer, unseat the check-valve *36,* and flow to passage *m1* and the main-reservoir pipe, thereby charging

the main reservoirs on the engine to a pressure dependent on the tension of the spring *39*.

103. Quick-Release Valve.—Two quick-release valves, Fig. 16, are installed in the brake-cylinder pipe, one for the front brake cylinders and one for the rear. The function of the quick-release valve is to provide a fast release of the locomotive brake. During a brake application, air from the distributing valve on its way to the brake cylinders, enters at *A* above piston *9*. The piston moves down, as it has a sliding fit on its stem *3*, thereby permitting the air to pass to the brake cylinders through the pipe connection at *B*. The spring seats the piston against the vent-valve stem nut when the difference between the air pressures in *A* and *B* is equal to the tension of the spring. When the brake is being released, the air escapes from above the piston, at the brake-cylinder exhaust port of the distributing valve; the brake-cylinder pressure beneath the piston now causes it to unseat the vent valve *4*. The air from the brake cylinders now escapes at *X*, until completely vented when the vent valve seats.

NO. 8 ET LOCOMOTIVE BRAKE EQUIPMENT

Serial 5201 Edition 2

DESCRIPTION AND OPERATION

DEVELOPMENT

1. The No. 8 ET locomotive brake equipment resembles the No. 6 ET locomotive brake equipment in many respects. Both equipments employ a distributing valve, an automatic brake valve, and an independent brake valve. Also, the general operation of both equipments is similar, but additional features are incorporated in the No. 8 ET locomotive brake equipment to meet changes in operating conditions that have developed since the introduction of the No. 6 locomotive brake equipment. The introduction of the No. 8 ET locomotive brake equipment was due largely to the necessity for a better control of the slack in the operation of long freight trains, and this factor required the addition of several features not found in the earlier equipment. With the No. 8 ET locomotive brake equipment, the locomotive brake and the train brakes apply uniformly in service applications on both a time and a pressure basis. This action is accomplished through the medium of a reduction chamber incorporated in the distributing valve, which acts to delay the beginning of the development of an effective brake-cylinder pressure on the locomotive to coincide with that on the cars; then the pressure in the brake cylinders on the locomotive and on the cars build up at a uniform rate. Also, during emergency applications, the slack in the train is controlled according to the service. Thus the brake-cylinder pressure on the locomotive can be made to develop rapidly when handling passenger trains and short freight trains, whereas the build-up of pressure can be delayed, or controlled, on long freight trains.

2. In addition to the foregoing features for the effective control of slack, the brake valve has a first-service position for

use with long trains on which the brake-pipe pressure is usually progressively lower from the front to the rear. With this condition, the normal service brake-pipe reduction tends to develop the braking force at the head end of the train faster and to a higher value than on the rear, thereby causing slack action. This action is overcome by the use of first-service position, which reduces the brake-pipe pressure more uniformly on all parts of the train.

The following are other desirable features of this equipment: Should the application pipe break, the only feature affected is the maintaining feature in emergency. If the release pipe breaks, it affects only the release of an automatic application with the independent brake valve or the fast release of the driver brakes. The pressure chamber has also a retarded charging feature, the purpose of which is to guard against an overcharge of this chamber during a release, thereby eliminating the dragging of the brakes and the heating of the tires caused by a slight unnoticed reapplication after a release of the train brakes. This feature may be cut out on short trains where an overcharge is not probable and where a fast recharge is desirable. The application portion of the distributing valve is much more sensitive to changes of pressure than with the No. 6 ET equipment.

PARTS OF NO. 8 ET LOCOMOTIVE BRAKE EQUIPMENT

3. Names of Parts.—The essential parts of the No. 8 ET locomotive brake equipment, Plate 11, are as follows: Two steam-driven air compressors; two or more main reservoirs; a compressor governor; a steam throttle valve; two air filters for the governor and the steam throttle valve; and the following devices all located on a pedestal in the cab; an automatic brake valve, with an equalizing discharge valve, an independent brake valve, a feed-valve, a reducing valve, an emergency relay valve, a signal-line fixture, a double-heading cock and a first-service position cut-out cock. Additional devices comprise a combined equalizing and reduction limiting reservoir; two duplex air gages; a distributing valve with a controlled-emergency valve which is set in either one of its two positions by a controlled-emergency cock on the independent brake-valve bracket; the

automatic slack adjuster; two brake-pipe vent valves; driver, truck, and tender brake cylinders; one or two air filters in the main-reservoir line; a tender drain cup; and various cut-out cocks, hose connections, dummy couplings, fittings, etc.

4. **Purpose of Parts.**—The air compressors supply the compressed air for use in the brake system.

The main reservoirs store and cool the compressed air.

The compressor governor controls the operation of the compressor and regulates the air pressure maintained in the main reservoirs.

The steam throttle valve protects the air compressors from damage by restricting the compressor speed when the main-reservoir pressure is low.

The two air filters for the governor and the steam throttle valve protect the regulating portions of these parts by removing all foreign matter from the air supplied to these devices.

The automatic brake valve controls the operation of the train and the locomotive brakes.

The independent brake valve controls the operation of the independent brake on the locomotive.

The feed-valve automatically maintains a predetermined normal air pressure in the brake system with the automatic brake valve in running position.

The reducing valve reduces main-reservoir pressure for independent brake operation and supplies air for the signal system.

The equalizing discharge valve functions to reduce brake-pipe pressure at the proper rate, regardless of the length of the train, with the brake valve in service position, and provides a relatively uniform reduction of brake-pipe pressure through a long train with maximum permissible brake-pipe leakage with the brake valve in first-service position.

The emergency relay valve provides a means of obtaining an emergency rate of brake-pipe reduction with the brake valve under all operating conditions.

The signal-line fixture, which comprises a check-valve, strainer, and choke, controls the supply of air from the reducing valve to the air-signal system.

The double-heading cock serves to cut out the automatic brake valve on the second locomotive when double-heading.

The first-service position cut-out cock is used to cut out the first-service position of the brake valve when desired.

The combined equalizing and reduction limiting reservoir is used with the equalizing discharge valve to provide for the proper functioning of this device.

One of the duplex air gages indicates equalizing-reservoir and main-reservoir pressures, and the other registers brake-pipe and locomotive brake-cylinder pressures.

The distributing valve when actuated by either brake valve permits air to flow into the brake cylinders, maintains any desired pressure in the brake cylinders, and permits the air to exhaust from the brake cylinders.

The controlled-emergency valve, in its control position, connects the pressure chamber of the distributing valve by way of a choke to the application chamber and the application cylinder during an emergency application on a long freight train, thus producing a controlled application. The valve in non-control position connects the pressure chamber to the application cylinder only in emergency applications on passenger trains and short freight trains, thus producing a rapid application.

The controlled-emergency cock, in combination with the controlled-emergency pipe, controls the flow of main-reservoir air to the controlled-emergency valve in such a manner as to cause it to assume either its control or non-control position.

The automatic slack adjuster maintains the piston travel of the tender brake cylinder at a predetermined amount.

The brake-pipe vent valves, one on the engine and one on the tender, insure the transmission of quick action that may originate on the locomotive to the train or the reverse. The driver, truck, and tender brake cylinders with their pistons and rods connected to the brake levers, serve to transmit the pressure of the compressed air to the brake shoes and the wheels. One or two air filters are so located in the main-reservoir line as to prevent dirt and moisture from entering the distributing valve, the feed-valve, and the reducing valve. Also, a centrifugal dirt collector is placed in the brake-pipe branch to the distributing valve.

GENERAL ARRANGEMENT OF APPARATUS

5. Names of Pipes and Parts Connected.—The names of the pipes and the parts connected by them are shown in the piping diagram, Plate 11.

The discharge pipe connects the air compressors to the first main reservoir.

The connecting pipe, also known as the radiating pipe, connects the two or more main reservoirs.

The main-reservoir pipe connects the last main reservoir to the brake-valve pedestal and to the distributing valve.

The high-pressure operating pipe connects the main-reservoir pipe to the high-pressure head of the compressor governor.

The low-pressure operating pipe connects the automatic brake valve to the low-pressure head of the compressor governor.

The brake pipe connects the brake-valve pedestal to the distributing valve and to all of the triple valves or universal valves on the cars in the train.

The brake-cylinder pipe connects the distributing valve to the driver, tender, and truck brake cylinders.

The application pipe connects the distributing valve to the brake-valve pedestal.

The application pipe charges with brake-cylinder air during automatic brake applications, and with air at reducing-valve pressure during independent brake applications, and the pipe conveys feed-valve air to the application cylinder in emergency application. In running positions of the brake valves and in an independent release after an automatic service or emergency application, the pipe conveys air from the application cylinder and chamber to the exhaust port of the brake valve that is being operated.

The independent release pipe connects the distributing valve to the brake-valve pedestal. This pipe conveys air at reducing-valve pressure to the face of the independent release piston in the distributing valve during an independent release after automatic service and emergency, and exhausts the air therefrom in running position of the independent brake valve.

The equalizing reservoir pipe connects this reservoir, which has a volume of 3,023 cubic inches, to the brake-valve pedestal.

The reduction limiting reservoir pipe connects the reduction limiting reservoir, which has a volume of 200 cubic inches, to the brake-valve pedestal.

The signal pipe is used to store air for the operation of the signal system.

The controlled-emergency pipe connects the controlled-emergency valve of the distributing valve to the cock on the independent brake valve bracket.

The controlled-emergency cock when in freight position admits main-reservoir air to this pipe. In passenger position of this cock as well as in quick-application position of the independent brake valve, the pipe is open to the atmosphere.

The main-reservoir gage pipe conveys main-reservoir air from the brake-valve pedestal to the red hand of the large air gage.

The equalizing-reservoir gage pipe conveys equalizing-reservoir air from the brake-valve pedestal to the black hand of the large air gage.

The brake-cylinder gage pipe connects the brake-cylinder pipe to the red hand of the small air gage.

The brake-pipe gage pipe conveys brake-pipe air from the brake-valve pedestal to the black hand of the small air gage.

6. Pipes at Distributing Valve and at Brake-Valve Pedestal.—The distributing valve, Plate 11, has six pipes connected to it, namely, the brake pipe, the independent release pipe, the application pipe, the main-reservoir pipe, the controlled-emergency pipe, and the brake-cylinder pipe.

The brake-valve pedestal has eleven pipes connected to it, seven to the base of the pedestal and four to the side. The names of the pipes connected to the base are as follows: The signal pipe, the brake pipe, the main-reservoir pipe, the equalizing-reservoir pipe, the reduction limiting reservoir pipe, the application pipe, and the independent release pipe. The four pipes connected to the side of the pedestal are the main-reservoir gage pipe, the equalizing-reservoir gage pipe, the low-pressure gover-

nor operating pipe, and the brake-pipe gage pipe. The controlled-emergency pipe is connected to the independent brake valve.

7. **Pipe Fixtures.**—The piping of the No. 8 ET locomotive brake equipment is supplied with various fixtures such as cut-out cocks, chokes, branch-pipe tees, etc. The 1-inch main-reservoir cut-out cock is for the purpose of shutting off main-reservoir air from the brake system when it is necessary to repair any part of the apparatus except the governor with the brake system charged. The cut-out cock contains a small bleed hole that allows the air to escape from the piping to the atmosphere when the cock is closed. Before this cock is closed, the double-heading cock should be closed, and the handle of the automatic brake valve placed in release position. This prevents the slide valve of the feed-valve and the rotary valve of the brake valve from being lifted from their seats.

The cut-out cock in the main-reservoir pipe to the distributing valve is used when necessary to shut off the main-reservoir air from the distributing valve and so prevent it from operating.

The three-way cock in the piping between the driver brake cylinders and the distributing valve is used when necessary to cut out these brake cylinders. This cock when closed has a vent that permits any air in the brake cylinders to escape. The cock is known as a three-way cock because it can be used either to permit or to prevent the flow of air to the brake cylinder as well as to vent the brake-cylinder air to the atmosphere.

The $\frac{1}{2}$-inch cut-out cock in the pipe to the truck brake cylinder is used to cut out this brake cylinder when necessary. The $\frac{3}{4}$-inch cut-out cock in the pipe to the tender brake cylinder is used to cut out this brake cylinder when desired. The same applies to the $\frac{1}{2}$-inch cut-out cock in the pipe to the trailer brake cylinder. All cocks stand crosswise of the pipes when open. The choke fittings in the three cut-out cocks just named prevent the total loss of brake-cylinder pressure from the other brake cylinders in the event of the bursting of a hose leading to any one of the cylinders. The distributing valve can maintain the pressure in the other brake cylinders against the flow of air through the choke at the burst or uncoupled hose.

Cut-out cocks are also located in the signal pipe, and in the main-reservoir branch pipe to the distributing valve.

Four branch-pipe tees are used: one where the branch pipe is taken off the brake pipe for the distributing valve, one where the branch pipe is taken off the main-reservoir pipe for the distributing valve, and one in the brake pipe on the tender, one on the engine for the branch connections to the brake-pipe vent valves, and one on the engine for the branch from the brake pipe to the brake valve. The purpose of the branch-pipe tees is to prevent moisture that may be deposited in the main pipes from draining into the branch pipes and from there into the valves.

The interior coring of a branch-pipe tee is so designed that the outlet from the main pipe to the branch pipe is at the top. Thus, as air enters from the main pipe, it flows upward and thence through the opening at the side to the branch pipe; the moisture and heavy particles of dirt pass on through the main pipe.

MANIPULATION

8. Automatic Operation.—The instructions for manipulating the No. 8 ET locomotive brake equipment are as follows: When the equipment is not in use, carry the handles of both brake valves in running position. To apply the brakes in first-service position, move the handle of the brake valve to this position until the required brake-pipe reduction is made, and then move it forward to lap position. First-service position was designed to be used when stopping long freight trains and, if operating conditions do not warrant its use, this position can be cut out by closing the small cut-out cock installed in the brake-valve housing.

To apply the brakes by the use of the ordinary service position, move the handle of the brake valve to this position until the required brake-pipe reduction has been made, then move the handle back to lap position. One service position does not have to be used to the exclusion of the other one, as explained under Instructions for Making Stops, given farther on.

To release the train brakes, move the handle of the brake valve to full release position; to release the locomotive brake,

move the brake-valve handle to running position. To apply the brakes in emergency, move the handle of the automatic brake valve quickly to emergency position and leave it there until the train stops.

9. Independent Operation.—When using the independent brake valve only, carry the handle of the automatic brake valve in running position.

To apply the locomotive brake, move the handle of the independent brake valve to either slow or quick-application position until the desired brake-cylinder pressure is obtained as indicated by the gage, then move the handle to lap. To release the locomotive brake after an independent application, place the handle of the brake valve in running position. To release the locomotive brake after an automatic application, move the handle of the independent brake valve to release position. The handle of the independent brake valve should always be left in slow-application position when leaving the engine, when doing work about it, or when it is standing at a coal chute or a water plug.

10. Double Heading.—In double-heading or helper service, close the double-heading cock behind the automatic brake valve on all engines except the one from which the brakes are being operated, and keep both brake valves in running position. The brakes on the helper engines can be applied or released at any time by using the independent brake valve. Also, an automatic emergency application is available at all times on the helper engines because the closing of the double-heading cock does not interfere with the operation of the emergency relay vent valve. On a helper locomotive, when the brake is applied from the operating locomotive, there will be an escape of air at the automatic brake-valve exhaust, caused by the supply of brake-cylinder air to the application pipe. The pressure in the locomotive brake cylinders is not affected by this blow because the pressure is kept supplied by the distributing valve through a choke communicating with the application pipe.

11. Dead Engine.—If an engine is being towed dead in a train or has no air in its main reservoir because of compressor failure, place both brake valves in running position, close the

double-heading cock, and change the dead-engine cap on the distributing valve to dead-engine position. In this position the word *dead* on the cap is over the letters *Eng* on the distributing-valve body.

12. Positions of Cocks.—In Fig. 1 appears a reproduction of a cab card which shows the positions of the two cocks at

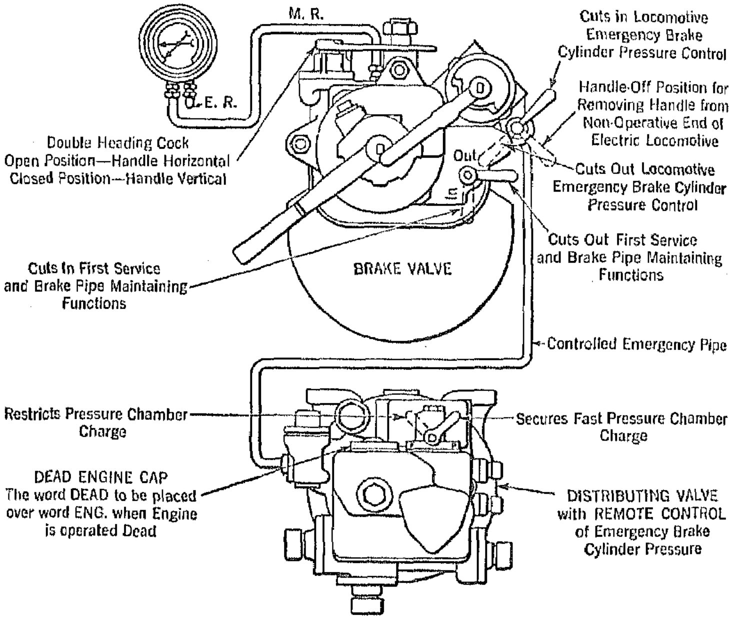


FIG. 1

the brake valves and of one at the distributing valve. The names of the two cocks at the brake valves are: the controlled-emergency cock on the independent brake valve bracket; the first-service position cock on the automatic brake valve body. At the distributing valve is the retarded recharge control cock.

For long freight trains the handle of the controlled-emergency cock should be in the control position, with the handle turned all the way to the left; and for passenger trains, short freight trains, and when moving the engine alone, the handle should be in the non-control position, with the handle turned all the way to the right.

For long freight trains, the handle of the first-service position cock should be turned over the word *In* on the body if it is desired to use first-service position of the brake valve; and for passenger trains and short freight trains, the handle should be

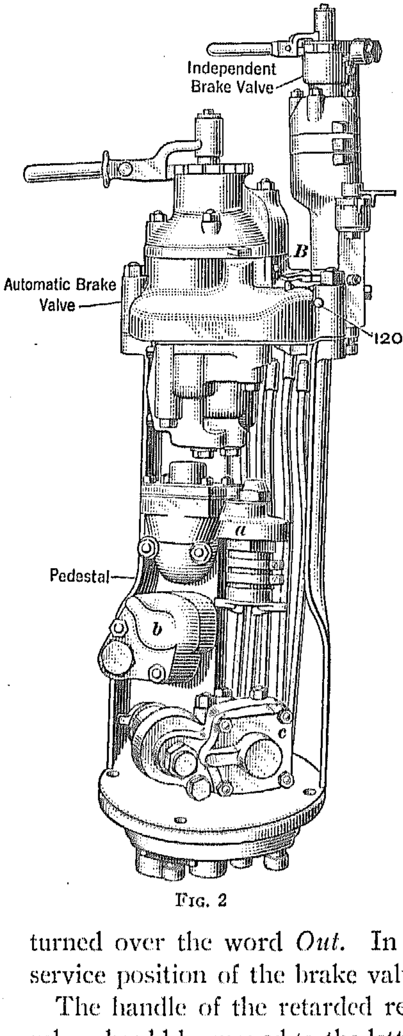


Fig. 2

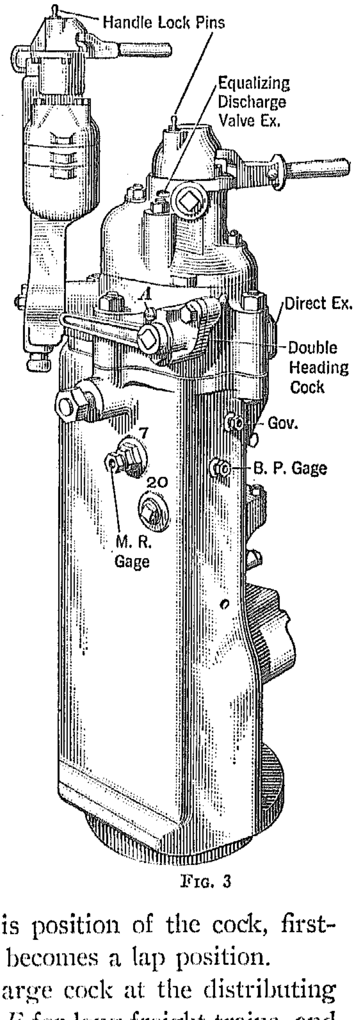


Fig. 3

turned over the word *Out*. In this position of the cock, first-service position of the brake valve becomes a lap position.

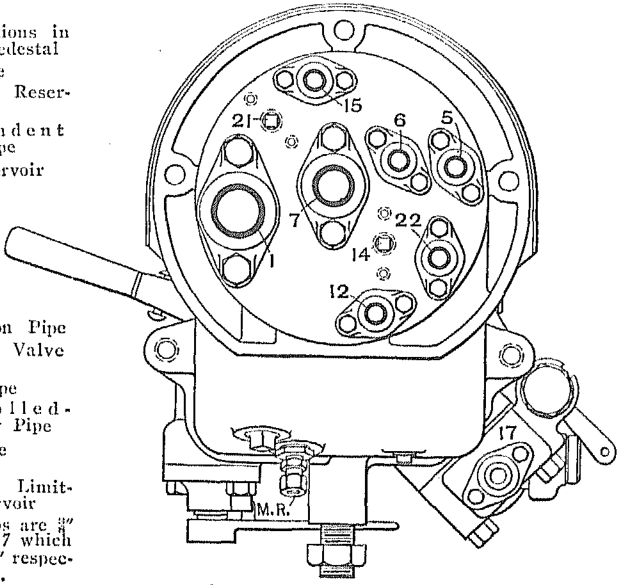
The handle of the retarded recharge cock at the distributing valve should be moved to the letter *F* for long freight trains, and to the letter *P* for short freight trains and passenger trains.

L-8-PA PEDESTAL BRAKE VALVE

PEDESTAL

13. A front view of the L-8-PA pedestal brake valve is shown in Fig. 2, and a rear view of a brake valve with quickly detachable handles is shown in Fig. 3. The complete assembly comprises a pedestal with the automatic brake valve mounted

Pipe Connections in Bottom of Pedestal
1—Brake Pipe
5—Equalizing Reservoir
6—Independent Release Pipe
7—Main Reservoir



12—Application Pipe
14—Reducing Valve (Plugged)
15—Signal Pipe
17—Controlled-emergency Pipe
21—Sand Pipe (Plugged)
22—Reduction Limiting Reservoir
All Pipe Taps are 3/8" except 1 and 7 which are 1 1/4" and 1" respectively.

FIG. 4

on the top, a feed-valve *a*, a combined emergency relay vent valve and signal-line fixture *b* bolted to the side, and a reducing valve *c* bolted to the upper face of the base of the pedestal. The independent brake valve is supported on a bracket attached to the lower portion of the automatic brake valve.

The left side of the pedestal contains numerous vertical and horizontal cored passages for the flow of air, so that this side has to be made thicker than the other side where the passage of air is through pipes.

A holding stud in the back of the pedestal and three holes in the base are provided to secure the pedestal to the back boiler head and to the floor of the cab. All of the iron pipe connections are made to the base of the pipe bracket beneath the floor sheet by means of reinforced fittings; thus, when making heavy locomotive repairs, it is only necessary to break the pipe connections and lift the complete pedestal from the cab. Numbers cast on the base of the pedestal as shown in Fig. 4 indicate where each connection is to be made. The number assigned to each connection and the name of the pipe coupled to it are as follows: *1*, brake pipe; *5*, equalizing-reservoir pipe; *6*, independent release pipe; *7*, main-reservoir pipe; *12*, application pipe; *14*, reducing valve (plugged); *15*, signal pipe; *17*, controlled-emergency pipe; *21*, sand pipe (plugged); and *22*, reduction limiting reservoir pipe.

14. As shown in the diagrammatic view of the brake valve, Plate 1, the cored passage *1* in the pedestal for the flow of brake-pipe air has a side outlet *1c* that communicates with the combined relay vent valve and signal-line fixture and one to which the black hand of the gage is piped. A side outlet from the cored passage to which the signal pipe is connected, also is in communication with this fixture. The passage *7* in the pedestal to which the main-reservoir pipe connects has a branch passage *7d* through the base to the reducing valve, another passage *7b* through the body of the pedestal to the feed-valve, and a branch passage *7a* to which the red hand of the gage is piped. A passage *14b* in the base conveys air at reducing-valve pressure to the signal pipe and through passage *14* to the chamber above the rotary valve of the independent brake valve. The passage *20* conveys air at feed-valve pressure to the chamber above the rotary valve of the automatic brake valve. For the other four pipe connections, namely, the connection for the equalizing-reservoir pipe, the reduction limiting reservoir pipe, the application pipe, and the independent release pipe, four pipes are used to convey the air from the base to passages in the upper portion of the pedestal. The equalizing-reservoir hand of the air gage is piped to a passage in the pedestal that is connected to passage 5.

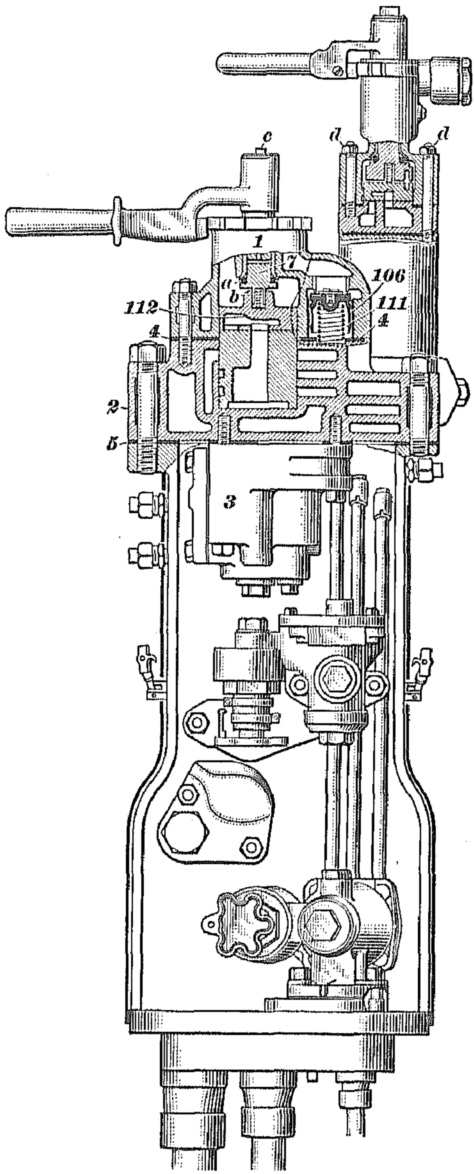


FIG. 5

AUTOMATIC BRAKE VALVE

15. Top Case.—The automatic brake valve is used to control the operation of the train and the locomotive brakes. It is bolted to the top of the pedestal and comprises, as shown in the partial sectional view, Fig. 5, three principal portions; the top case *1*, the rotary valve seat *2*, and the equalizing piston valve portion *3*. These portions are separated by gaskets *4* and *5*. The top case is bolted to the rotary-valve seat and contains three valves; a charging valve *106*, with a spring *111*, a rotary valve *112*, and an exhaust valve *97*, Plate 1. The rotary valve controls the passage of the air for the operation of the brakes in accordance with the positions of the handle of the brake valves.

The charging valve supplies main-reservoir air for the rapid charging of the brake pipe in release position and is operated by a difference in air pressures. The exhaust valve is opened in first-service, service, lap, and emergency postions by the engagement of a cam *a* on the rotary-valve key *b* with a pawl *c*, Fig. 6. When the end of the pawl is forced against the stem *97*, of the exhaust valve *98*, the valve is unseated against the tension of its springs and permits brake-pipe air to escape from passage *d* through passage *e* to the atmosphere in the positions just mentioned. In the other positions of the brake valve, the exhaust valve is held seated by its spring and hence prevents any venting of brake-pipe air should the equalizing piston lift in full release and running positions.

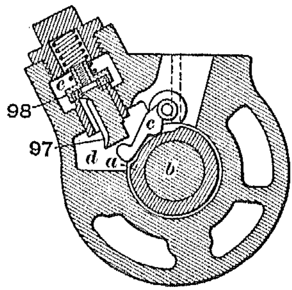


FIG. 6

Suitable shoulders or stops are cast on the projecting flange of the top case, Fig. 7, and the different positions of the brake valve are indicated when the latch in the brake-valve handle engages these stops. The brake valve has six positions; release, running, first-service, lap, service, and emergency. The brake-valve handle has a feeler button, which moves in and out as the latch passes over the quadrant shoulders and notches during

the movement of the handle; thus the engineman can feel the handle position from its movement. A feeler button on both sides of the handle provides for either right- or left-hand operation.

The brass rotary valve *112*, Fig. 5, which operates within a ring cast on the interior of the top case, is rotated on the raised central portion of the rotary-valve seat by the brake-

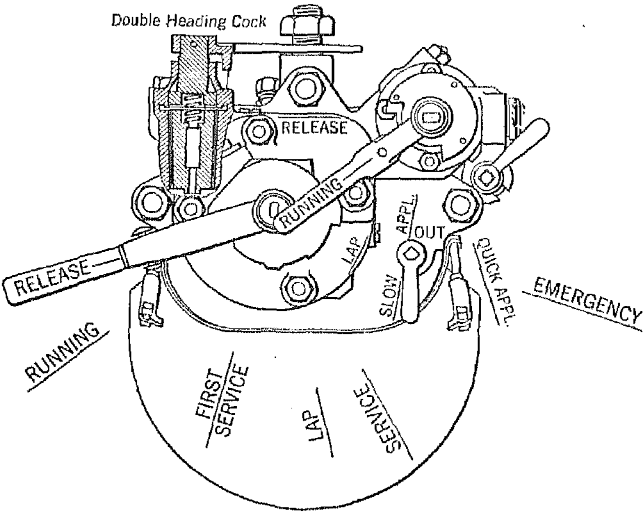


Fig. 7

valve handle through the medium of the rotary-valve key *7*. The end of the key is wedge-shaped and fits in a slot in the top of the rotary valve.

When the rotary valve is turned by means of the handle and the rotary-valve key to the different brake-valve positions, the proper communication is established for the flow of air to cause the desired operation of the brakes.

The escape of air past the rotary-valve key is prevented by the leather key washer *a*. The rotary-valve spring *b* holds the rotary-valve key up against the key washer and also holds the rotary valve on its seat during the time the brake valve is not charged with air pressure. An oil passage in the rotary-valve

key closed by the cap nut *c* employed to hold the brake-valve handle on the key is used to apply oil to the key washer.

16. **Rotary-Valve Seat.**—The rotary-valve seat, Plate 1, contains numerous passages for the flow of air most of which terminate in ports in the surface of the raised central circular portion on which the rotary valve operates. This portion of the brake valve has two cocks, the double-heading cock *84* by means of which the automatic brake valve is cut out on the second locomotive when double-heading, and the first-service position cut-out cock *80*, used to cut out the first-service position of the brake valve when desired. With this latter cock closed, air is prevented from flowing to the reduction limiting reservoir and to the maintaining valve in the equalizing piston valve portion of the brake valve.

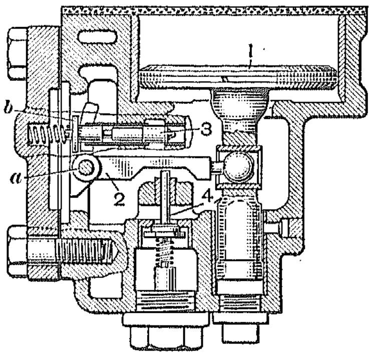


FIG. 8

The rotary-valve seat also has two plugs *A* and *B*, and a choke *120*, Figs. 2 and 3, the purpose of which is explained under the operation of the equipment. As shown in Fig. 5, the rotary-valve seat proper is a plug, press-fitted into the seat; this construction is used solely for manufacturing reasons. This plug is not removable and no attempt should be made to remove it.

17. **Equalizing Piston Valve Portion.**—The equalizing piston valve portion is attached by studs to the under side of the automatic brake valve and its function is to control the rate at which brake-pipe pressure is reduced in first-service and service positions.

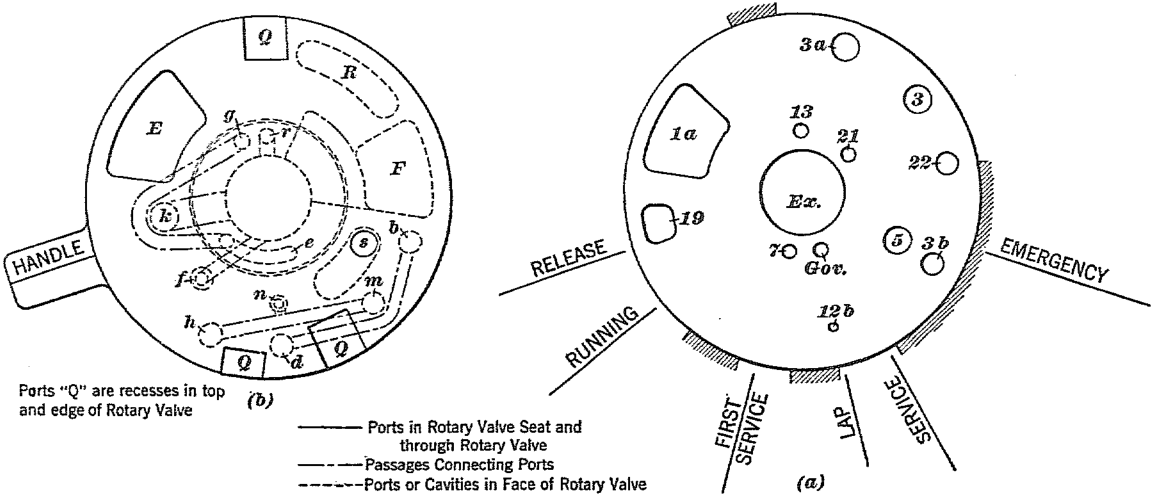
A sectional view of the portion is shown in Fig. 8. The movable parts comprise an equalizing piston *1*, an operating lever *2*, a discharge valve *3*, and a maintaining valve *4*. The action of the parts can be best understood from the following: The chamber above the equalizing piston is connected to the

equalizing reservoir and the chamber beneath it to the brake pipe. Both chambers charge at the same rate in release and running positions of the brake valve, so that the equalizing piston remains down in the position shown. In service position, the pressure in the equalizing reservoir and above the piston is reduced; the brake-pipe pressure below the piston then raises it and carries the ball-shaped end of the operating lever upward. The short end of the lever pivots on the pin *a* and engages the collar *b* on the discharge valve, unseating it and thereby permitting the brake-pipe air to pass through a passage in the rotary-valve seat and in the top case to the exhaust valve and thence to the atmosphere. When the reduction in the brake pipe about equals that in the equalizing reservoir, the piston moves down; the lever then returns to its original position and the discharge valve is seated by its spring.

The maintaining valve operates in the first-service position of the brake valve and then only when the reduction in brake-pipe pressure due to leakage occurs at a higher rate than the reduction in equalizing-reservoir pressure. In such an event, the higher pressure in the equalizing reservoir forces the piston to its lower position, thereby depressing the operating lever and unseating the maintaining valve. Air at feed-valve pressure then passes by the maintaining valve to the brake pipe and limits the rate of brake-pipe reduction to that of the controlled reduction in the equalizing reservoir. This feature is known as the uniform brake-pipe reduction feature for long trains.

It was the introduction of the maintaining valve that made it necessary to provide a different method from that employed with other brake valves for the discharge of air from the brake pipe in service position.

18. Rotary Valve and Seat of Automatic Brake Valve.—A top view of the rotary-valve seat is shown in Fig. 9 (*a*) and a view of the face of the rotary valve that rests on this seat is shown in (*b*). The legend shown under these illustrations is self-explanatory and no further description is necessary.



PORTS IN VALVE SEAT

1a	Brake Pipe	12b	Maintaining Emergency
3	"U" Port	13	Charging Valve
3a	Plug "A"	19	Maintaining Brake Pipe
3b	Plug "B"	21	Sanding Port
5	Equalizing Reservoir	22	Reduction Limiting Res.
7	Main Reservoir	Ex.	Exhaust

Fig. 9

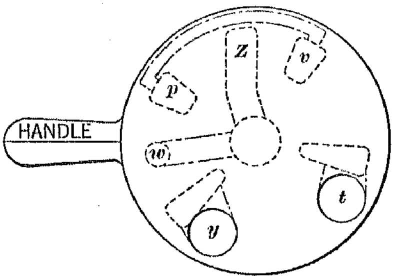
INDEPENDENT BRAKE VALVE

19. The independent brake valve is supported on a bracket, Fig. 5, bolted to the rotary-valve seat of the automatic brake valve. The complete valve can be lifted from the bracket by removing the nuts from the studs *d*. This valve is similar, with the exception of a poppet valve, to the S-6 independent brake valve used with the No. 6 ET equipment, hence an extensive description is unnecessary. The five positions of the brake-valve handle beginning at the extreme left, Fig. 7, are release, running, lap, slow application, and quick application. As with the S-6 brake valve, a return spring automatically moves the handle from quick-application to slow-application position and from release to running position. The automatic return from release to running position is to prevent leaving the handle in release position, which would make it impossible to operate the locomotive brake with the automatic brake valve. The action of the spring between quick-application and slow-application positions serves to make the latter position more prominent so that, in the rapid movement of the handle, the engineman is less likely to pass over unintentionally to quick-application position and thus obtain a heavy application of the locomotive brake when only a light one is intended.

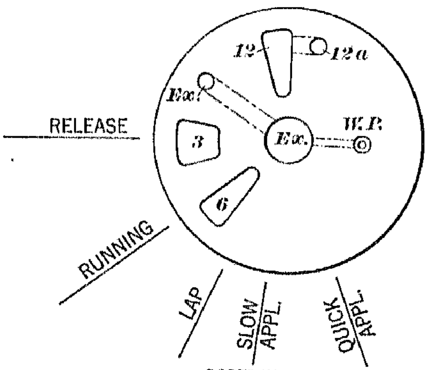
The controlled-emergency cock, Fig. 2, is incorporated with the independent brake valve bracket. This cock, when turned to freight position, connects air at main-reservoir pressure to the controlled-emergency pipe and the controlled-emergency valve on the distributing valve, thereby moving it to control position. When the cock is turned to passenger position, the cock vents main-reservoir air from the controlled-emergency pipe and from the controlled-emergency valve, which then assumes non-control position.

The poppet valve *180*, Plate 1, is incorporated with the independent brake valve body. This valve makes it possible to bring about a much faster application of the locomotive brake in emergency than otherwise when the controlled-emergency cock is in *freight* position. This valve also permits of a faster application of the brake in quick-application position.

In this position of the cock, the controlled-emergency valve is in control position and the locomotive brake applies slowly during emergency applications owing to the air in the pressure chamber passing through a choke to the application chamber



——— Ports in Rotary Valve Seat and through Rotary Valve
—·— Passages Connecting Ports
– – – Ports or Cavities in Face of Rotary Valve



PORTS IN VALVE SEAT

3	"U" Port
6	Independent Release Pipe
12	Quick Application Pipe
12a	Slow Application Pipe
W. P.	Warning Port.
Ex.	Exhaust.

Fig. 10

and application cylinder. However, if the handle of the independent brake valve is moved to quick-application position before or at the same time that the automatic brake valve is moved to emergency position and is held there, the controlled-emer-

gency valve will move to non-control position, in which position the pressure-chamber air is vented to the application cylinder alone, and the locomotive brake will apply rapidly.

When the poppet valve is unseated in quick-application position, the air is vented from passage *17* and the controlled-emergency pipe at a faster rate than main-reservoir air can flow to this pipe through the choke in the controlled emergency cock *186* when it is in freight position. The emergency control valve will then move to non-control position, but as soon as the handle of the independent brake valve is released and moves to slow-application position, the emergency control valve will return automatically to control position.

A view of the face of the rotary valve and of the seat of the independent brake valve is given in Fig. 10.

COMBINED EMERGENCY RELAY VENT VALVE AND SIGNAL-LINE FIXTURE

20. The combined emergency relay vent valve and the signal-line fixture, although combined in one unit that is removable, have separate and distinct functions. The relay vent-valve piston *49*, Plate 1, functions only in an automatic emergency application, at which time main-reservoir air is admitted against its face. The piston is then forced against the tension of its spring, and unseats first the pilot valve *39* and next the vent valve *36*, which valve then permits the escape of brake-pipe air in a large volume.

The signal-line fixture consists of a curled-hair strainer *52*, a check-valve *53* with a spring *54* and a choke *33*. The air from the reducing valve flows through the strainer, unseats the check-valve, and passes through the choke to the signal pipe. The check-valve prevents the air from flowing back from the signal pipe when the independent brake valve is applied, and the choke prevents the pressure in the signal pipe from increasing at a rate that would interfere with the proper operation of the signal valve. The air pressure in the signal pipe is slightly lower than the reducing-valve pressure of 45 pounds, owing to the spring loading of the check-valve *53*.

NO. 8-A DISTRIBUTING VALVE

GENERAL DESCRIPTION

21. Purpose.—In general, the purpose of the distributing valve is to apply the locomotive brake by admitting air from the main reservoirs to the brake cylinders on the engine and the tender, to release the brake by exhausting the air from the brake cylinders, and to maintain automatically the pressure in the brake cylinders against leakage after brake applications. The distributing valve acts as a reducing valve when admitting air

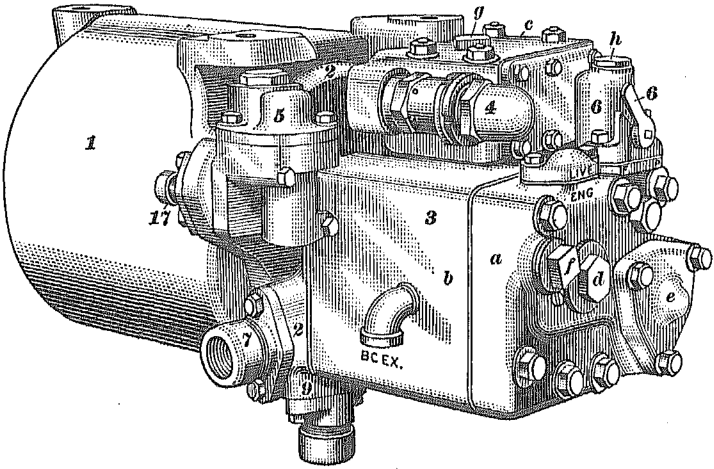


Fig. 11

from the main reservoir to the brake cylinders; the pressure developed in the brake cylinders is then always less than main-reservoir pressure.

22. Portions of Distributing Valve.—An exterior view of one side of the distributing valve is shown in Fig. 11, and in Fig. 12 is shown a view of the other side of the valve.

The distributing valve consists of three main portions, namely, a double-chamber reservoir *1*, one chamber being the pressure chamber with a volume of 1,000 cubic inches and the other one the application chamber, with a volume of 238 cubic inches; a pipe bracket *2*, to which all of the pipe connections are made

and which contains a reduction chamber with a volume of 84 cubic inches; and an operating portion *3*. The operating portion, the outer end of which is closed by the cover *a*, comprises three sets of operative parts, namely, an application portion, an equalizing portion, and a reduction chamber cut-off valve and release-valve portion. The application portion and the equalizing portion with functions identical with similar parts found in the No. 6 distributing valve are contained within the casting *b*, and the reduction chamber cut-off valve and release-valve portion *c* is bolted to the top of this casting.

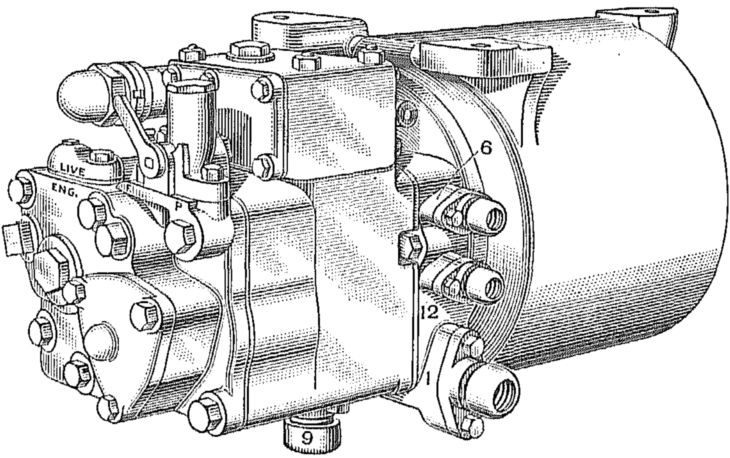


FIG. 12

The double-chamber reservoir, which is furnished with lugs for suspension mounting, may be regarded as a fixture after being installed, as it has no pipe connections and need never be disturbed. All of the pipe connections are made to the pipe bracket, so that the operating portion can be removed from the bracket as a unit without breaking any connections. Six pipes are connected to the pipe bracket by reinforced fittings, and numbers cast on the bracket indicate where each pipe is to be connected. The brake pipe, Fig. 12, is connected at *1*, the application pipe at *12*, and the independent release pipe at *6*. The brake-cylinder pipe, Fig. 11, is connected at *9*, the main-reservoir pipe at *7*, and the controlled-emergency pipe at *17*.

APPLICATION PORTION

23. Purpose.—The purpose of the application portion of the distributing valve, which is contained within the casting *b*, Fig. 11, of the operating portion, is to apply the locomotive brake, release the brake, and maintain, with the brake applied, a brake-cylinder pressure equal to that in the application cylinder.

24. Purpose of Parts.—The parts contained in the application portion and shown in Plate 1 are the application piston *23*, the exhaust slide valve *25*, the application valve *37* with a spring *45*, and a pilot valve *40* with a spring *44*. The four parts last named can be taken out by removing the cap nut *d*, Fig. 11, in the operating-portion cover but, before the application piston and the exhaust valve can be taken out, the operating portion must be removed from its pipe bracket.

The application piston *23*, Plate 1, directly controls the brake-cylinder pressure in accordance with the pressure that exists in the application cylinder *A* on its face. When air is delivered to the application cylinder from the pressure chamber in an automatic brake application or from the application pipe in an independent brake application, the application piston acts to reproduce in the brake cylinders on the locomotive, a pressure equal to that existing in the application cylinder. The application cylinder has a volume of approximately 12 cubic inches.

The exhaust slide valve *25* moves with the application piston and opens and closes the brake cylinders to the exhaust in accordance with the position of the piston.

The application valve *37* and the pilot valve *40* are operated by the application piston to supply air from the main reservoir to the brake cylinders. On a brake application, the end of the application piston first engages and unseats the pilot valve, and allows air from the spring chamber to flow to the brake cylinders. While the air escapes rapidly past the pilot valve, the choke *36* in the meantime supplies just enough air to the spring chamber to balance partially the pressures on both faces of the application valve by the time the piston stem engages this valve. In this way the application valve is prevented from opening abruptly and resistance to movement is reduced.

The springs *44* and *45* close the pilot valve and the application valve promptly when the application piston moves to lap after the required brake-cylinder pressure is obtained. Therefore, a very light difference in pressures is required on the application piston to move it to release.

The plug *78* is used when testing the valve on the test rack to determine the individual leakage of each of the two application-piston packing rings. The choke *3* permits air to enter behind the application piston and thereby steadies its movement to the right.

EQUALIZING PORTION

25. Purpose.—The purpose of the equalizing portion of the distributing valve, which operates within the casting *b*, Fig. 11, of the operating portion, is to bring about the operation of the application portion when the brake is being operated by the automatic brake valve only. At this time the equalizing portion controls the flow of compressed air from the pressure chamber to the application chamber and cylinder when the brake is being applied and its exhaust therefrom when the brake is being released.

26. Purpose of the Parts.—The parts that comprise the equalizing portion are the equalizing piston *10*, Plate 1, the equalizing graduating valve *16* with a spring, the equalizing slide valve *18*, the retarded recharge spring *13* and stem *14*, the graduating spring guide *28*, the graduating spring *31*, and the curled-hair strainer *32*. The three last-named parts can be taken out by removing the cap *e*, Fig. 11; the other parts can be removed by taking off the operating portion cover *a*.

The purpose of the equalizing piston, Plate 1, is to move the equalizing slide valve and the graduating valve as well as to open and close the feed-groove. The outer face of the piston is exposed to brake-pipe air and the inner face to pressure-chamber air.

The equalizing slide valve permits air to flow from the pressure chamber by way of the reduction-chamber cut-off valve to the application chamber, and the application cylinder when the brake is being applied, and between the application chamber,

the application cylinder, and the application pipe when the brake is being released.

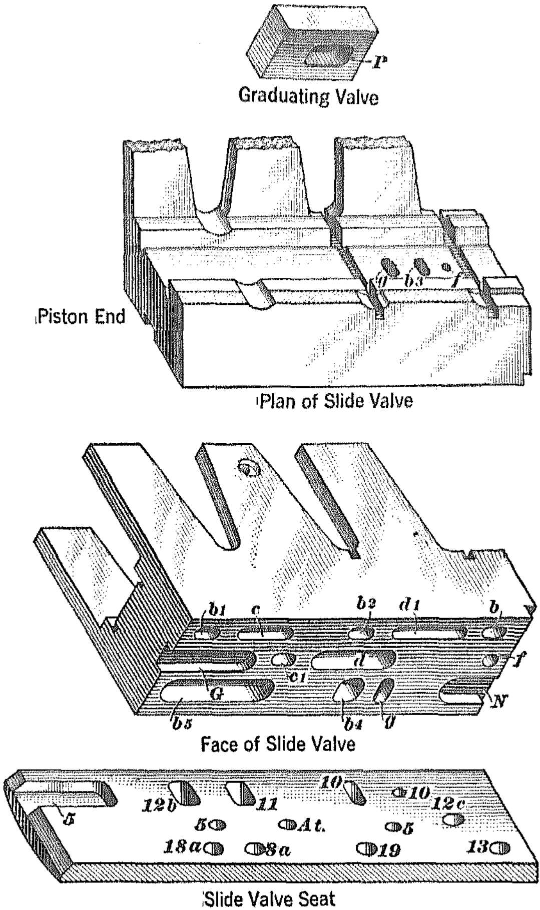


Fig. 13

The graduating valve opens and closes a port in the equalizing slide valve and thus graduates or measures the flow of air from the pressure chamber to the application chamber and the application cylinder during service-brake applications. The graduating valve also serves to break the connection between the application

cylinder and the safety valve in service lap position of the distributing valve.

The retarded recharge spring *13* returns the equalizing piston from retarded recharge to normal charging position when the air in the pressure chamber is built up to approximately brake-pipe pressure. The equalizing piston seal *26* restricts the charging of the pressure chamber to the capacity of choke *4* in retarded recharge position. The choke *127* provides a predetermined rate of release when releasing the brake in running position of either brake valve. The air in the application cylinder and the application chamber by-passes the choke and escapes through the cut-off check-valve instead, when the brake is released in release position of the independent brake valve.

In Fig. 13 is shown a face view of the graduating valve, a plan view and a face view of the equalizing slide valve, and a view of the equalizing slide-valve seat. The various ports and cavities are designated by the same reference letters as in the large plates of the equipment that accompany this lesson paper.

REDUCTION CHAMBER CUT-OFF VALVE AND RELEASE-VALVE PORTION

27. The cut-off valve and release-valve portion *c*, Fig. 11, is secured to the main part of the operating portion by four studs; an air-tight joint is made between the two castings by a gasket. This portion is provided a cover at each end.

This portion, Plate 1, comprises the reduction chamber cut-off piston *98*, the slide valve *101*, the spring *106*, the slide-valve strut and its spring, here shown under the valve, although these parts are actually on top of the valve; also the independent release piston *78* and the cut-off valve *96*. All of these parts with the exception of the release piston and the slide-valve strut and its spring can be removed by taking off the rear cover of the casting. The release piston can be removed by taking off the front cover, and the slide-valve strut and its spring can be taken out by removing the cap nut *g*, Fig. 11.

The operation of the reduction chamber cut-off piston and slide valve is dependent upon the movement of the equalizing slide valve.

When the equalizing slide valve moves to service position, the reduction chamber cut-off piston is caused to move its slide valve to a position that permits the air from the pressure chamber to flow to the reduction chamber until a pressure of 30 pounds is built up. A brake-pipe reduction of 4 pounds is required to develop this pressure in the reduction chamber. As the brake-pipe reduction continues, the piston moves the slide valve to cut-off position, where the valve blanks the passage to the reduction chamber and opens a passage that leads from the equalizing slide-valve chamber and the pressure chamber to the application cylinder and chamber. The slide-valve strut and its spring serve to keep the slide valve seated in the absence of pressure in the chamber of the cut-off slide valve at the start of the application.

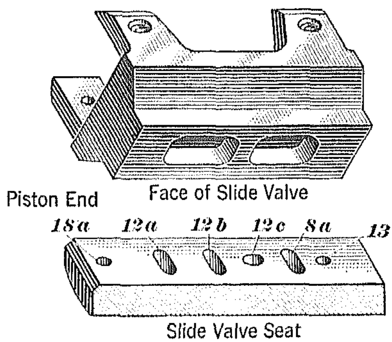


FIG. 14

In Fig. 14 is shown a perspective view of the face of the reduction chamber slide valve, and also a view of the face of the slide-valve seat. The ports in the seat are lettered to correspond with the large views of the equipment accompanying this lesson paper.

28. The purpose of the independent release piston *87*, Plate 1, is to unseat the cut-off valve *96* in release position of the independent brake valve, in which position air at reducing-valve pressure is admitted to the face of the piston. The purpose of the groove in the bushing of the release piston is to by-pass any air to the opposite side of the piston and to the exhaust port should the rotary valve of the independent brake valve leak. With no groove, and a leaky rotary, the piston would be forced over by the leak of air into the independent release pipe and open the cut-off check-valve, thus by-passing the choke *127* and preventing the predetermined slow release of the brake.

The cut-off valve *96*, when unseated, connects the application cylinder to the application pipe, thereby providing for an independent release of the locomotive brake. The cut-off valve also affords protection against the loss of the automatic brake with a broken application pipe by preventing a back-flow of air from the application cylinder and chamber to the broken pipe. This valve provides also the same development of brake-cylinder pressure for a given brake-pipe reduction with a short application pipe as used with a steam locomotive or a very long application pipe as used with an electric locomotive.

OPERATING PORTION COVER

29. The cover, Plate 1, which is bolted to the end of the operating portion of the distributing valve contains the graduating spring *31*, the graduating spring guide *28*, the curled-hair strainer *32*, the retarded recharge cock *70*, the ball check *73*, the strainer *48*, the maintaining check-valve *47* and spring *49*, a choke *34*, and the dead-engine feature consisting of a check-valve *52*, a spring *51*, and a choke *35*.

The strainer *48*, the check-valve *47* and its spring *49* can be taken out by removing the cap nut *f*, Fig. 11. The curled-hair strainer *32*, the spring guide *28*, and the graduating spring *31* can be removed by taking off the cap *e*. Access to the dead-engine fixtures is obtained by removing the cover *a*.

The arrangement of the graduating spring *31* and the spring guide *28* prevents the equalizing piston from moving past service position during service applications on short trains.

The curled-hair strainer *32* filters the brake-pipe air, thereby removing the fine particles of dirt and protecting the equalizing portion.

The retarded recharge cock *70*, Plate 1, which operates within a cover *6*, Fig. 11, bolted to the cover of the operating portion, provides a higher rate of pressure-chamber recharge than that provided through choke *4* in retarded recharge position of the equalizing piston. The letters *F* and *P* cast on the bracket indicate the two positions of the cock for freight and passenger service, respectively. In position *F* of the handle the recharge occurs through the feed-groove *V* and choke *4* as shown in Plate

1, and in position *P* the recharge is augmented by the flow by way of cock *70* and through choke *68*, thus providing a higher rate of recharge in passenger service. The ball check *73*, which can be taken out by removing the cap *h*, Fig. 11, prevents the back flow of air from the pressure chamber to the brake pipe.

The maintaining check-valve *47*, Plate 1, normally held seated by spring *49*, prevents the air that is entering the application cylinder during an independent application of the brake from escaping at the brake-cylinder exhaust port. The purpose of choke *34* is to restrict the flow of brake-cylinder air to the application pipe so that even though the application pipe should be broken off, the automatic brake will not release because the leakage at the break will be restricted to the capacity of the small choke and hence is easily maintained from the main-reservoir supply.

The dead-engine feature is incorporated in the distributing valve and is cut in or out by means of a cap, Fig. 11. When the word *Live* on the cap is over the word *Eng.* on the body, the cap is in *live-engine position,* and when the word *Dead* on the cap is over the word *Eng.*, the cap is in *dead-engine* position. The position of the cap is changed by removing the studs and turning it end for end.

With the cap set in dead-engine position, as shown in the upper right supplemental view, Plate 1, brake-pipe air from passage *1* flows through the strainer *32* and passage *1b*, unseats the spring-loaded check-valve *52*, and then flows through passage *1c* and choke *35* to passages *7b* and *7* and thence to the main reservoirs on the dead engine. In this position of the cap, air from the brake cylinders is prevented from passing from passage *12f* to passage *12*, and the application pipe because air is not being retained in this pipe on the dead engine during an application of its brake.

The spring *51* insures that the brake-pipe pressure is enough higher than the pressure in the main reservoirs of the dead engine to prevent a back flow to the brake pipe when the brakes are applied. The choke *35* prevents a reduction in brake-pipe pressure and thereby applies the brakes when a dead locomotive with empty main reservoirs is connected to a charged brake pipe.

CONTROLLED-EMERGENCY VALVE

30. The controlled-emergency valve *5*, Fig. 11, is bolted to the pipe bracket of the distributing valve and its purpose is to control the development of brake-cylinder pressure in automatic emergency applications to a fast or a non-controlled build-up of pressure for short freight and passenger trains and a controlled build-up for long freight trains.

The controlled-emergency valve is set in control position by moving the handle of the cock on the independent brake valve bracket to freight position and is set in non-control position by moving the handle to passenger position. However, even with the cock in freight position, the controlled-emergency valve can be moved to non-control position by using quick-application position of the independent brake valve, to unseat its poppet valve.

In non-control position, the controlled-emergency valve cuts off the application chamber from the application cylinder so that, in emergency applications, the air in the pressure chamber equalizes into the application cylinder only, thus producing a rapid application. In control position, the application chamber and cylinder are connected and the air in the pressure chamber equalizes through a choke into the combined application cylinder and chamber volumes, thereby producing in emergency applications a delay, controlled rate of application. This action will result in shocks of less severity in the train than otherwise.

31. The controlled-emergency valve, Plate 1, has the following operative parts: The delay piston *161*, the spring *165*, the delay slide valve *163*, ball check *170*, and rubber-seated check *167* with a spring *168*. The arrangement of the ball check, the rubber-seated check, and spring is for the purpose of bypassing the choke *128* when an independent release after an automatic emergency application is made, with the controlled-emergency valve in control position thereby obtaining a quick release. A view of the slide valve of the controlled-emergency valve and also a view of the slide-valve seat are shown in Fig. 15.

E-7 SAFETY VALVE

32. Purpose.—The purpose of the E-7 safety valve *4*, Fig. 11, a sectional view of which is shown in Fig. 16, is to prevent the development of too high a pressure in the locomotive brake cylinders. The safety valve is connected to the application cylinder in all positions of the distributing valve except automatic service lap. The safety valve is screwed into the reduction chamber cut-off valve and release-valve portion.

33. Operation.—When the pressure in cavity *A* under valve *4*, Fig. 16, is sufficient to overcome the pressure exerted by the tension of spring *6*, the valve is raised from its seat; the upward movement closes the upper end of port *a* in the valve bushing

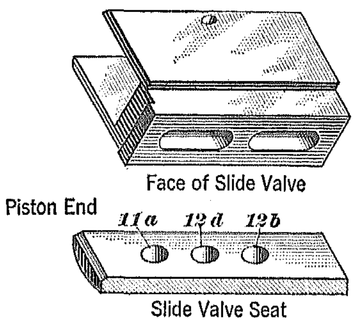


FIG. 15

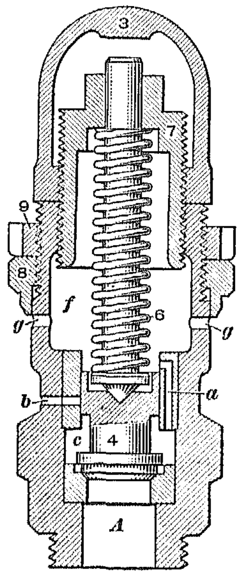


FIG. 16

and opens port *b*, permitting air to flow from cavity *A* through chamber *c* and port *b* to the atmosphere. As the pressure below valve *4* decreases, the tension of spring *6* forces the valve downward, which restricts the opening through port *b* and opens the upper end of port *a* to the spring chamber *f*. Although chamber *f* is open to the atmosphere at all times, the connecting ports *g* in the body are sufficiently small to restrict the exhaust, so that the pressure builds up rapidly in chamber *f* and assists spring *6* in forcing valve *4* quickly to its seat.

To adjust the safety valve for the the maximum or opening pressure, which in this case is 68 pounds, remove the cap nut *3* and screw down or back off the regulating nut *7*, as required, then replace the cap nut. The minimum or closing pressure for the safety valve used with this equipment is 65 pounds, and can be adjusted by changing the size of the ports *g*, the regulating nut *8* being used for this purpose. After making the adjustment, screw down the jam nut *9*.

BY-PASS CHECK-VALVES

34. The by-pass check-valve *5a*, Plate 1, by-passes the brake-pipe air around the strainer *32* during a recharge in case the strainer is restricted. Should the strainer be clogged by dirt to such an extent as to create a difference of 2 pounds between the pressure in the brake pipe in passage *1* and the pressure in chamber *B*, the higher pressure in passage *1f* will unseat the by-pass check-valve *5a* and the air will flow through passage *1b* to chamber *B*, thus by-passing the strainer.

The by-pass check-valve *5* by-passes the air around the strainer when the brake-pipe pressure is being reduced should the strainer be restricted. If the strainer should be obstructed by dirt to such an extent as to cause the brake-pipe pressure in passage *1f*, Plate 3, to be 2 pounds less than the pressure in chamber *B* and in passage *1b*, the greater pressure in passage *1b* will overcome the tension of the spring *7* and unseat the by-pass check-valve *5*. The air from chamber *B* then flows through passage *1b* past the check-valve 5 to passage *1f* and the brake pipe, thus by-passing the strainer.

Small projections or feet on the face of the check, permit of the passage of air by it, when the valve is forced to the left against its seat.

STEAM THROTTLE VALVE

35. The steam throttle valve, Plate 11, is installed between the steam valve and the governor in the steam supply line to the compressor with the top outlet connected to the pipe leading from the main reservoir to the high-pressure top of the governor. The purpose of this device is to control automatically the steam supply to the air compressor when the compressor

throttle is wide open. It permits a full supply of steam as long as the main-reservoir pressure is high enough to cushion the air pistons but restricts the flow whenever the main-reservoir pressure is not high enough for this purpose. With a main-reservoir pressure approximately 40 pounds or less, the steam throttle valve restricts the flow of steam to the compressor even if the compressor throttle is fully opened. This eliminates any liability of damage to the compressor pistons and heads caused

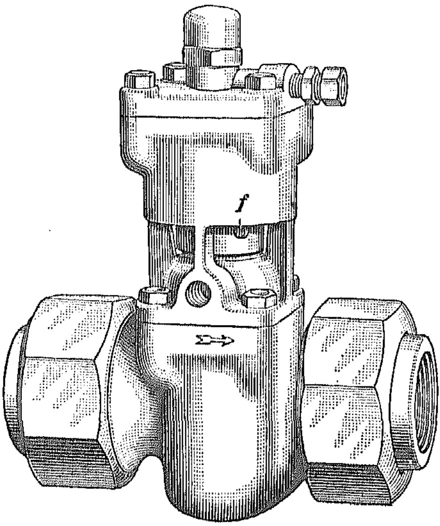


FIG. 17

by racing when there is insufficient main-reservoir pressure to cushion the pistons under full throttle operation.

36. An exterior view of the steam throttle valve is shown in Fig. 17, and in Fig. 18 is shown a sectional view with the valve in throttling position, or the position it assumes when the compressor is started with no pressure in the main reservoir. In this position the spring *a* holds the collapsible piston *b* in its upper position with the rim *c* sealing on gasket *d*. The area of the piston within the rim is exposed to main-reservoir pressure; the area outside of the rim is open to the atmosphere through the relief groove *e* and the hole *f* in the spring cup *g*. The piston *b* has a sliding fit on the stem *h* and has a shoulder that engages

the lower surface of the collar *i* on the upper end of the stem, thereby holding the spool *j* in its upper or throttling position and restricting the flow of steam to the compressor to the amount of the clearance shown around the spool. The compressor now makes approximately half the number of strokes per minute obtained under full throttle opening.

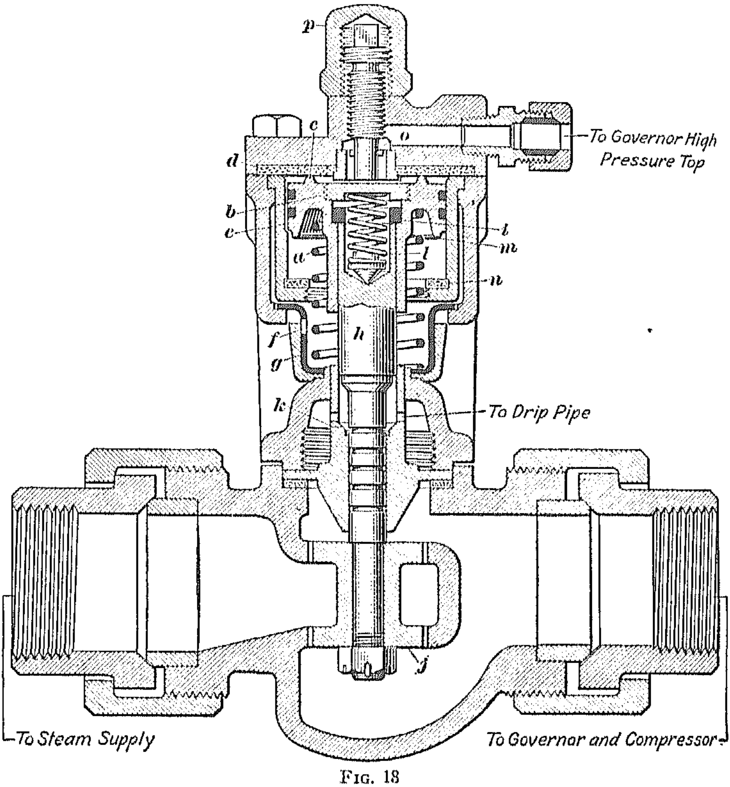


FIG. 18

When the main-reservoir pressure on the piston area within the rim *c* builds up to approximately 30 pounds, the tension of the spring *a* is overcome and the piston starts to move down. The first movement serves to break the seal at *d* and closes the groove *e*, thereby exposing an additional area to main-reservoir pressure. The increase in the total force on the piston causes it to move down quickly and thereby forces the stem downward.

With the seal broken, a pressure of only about 20 pounds would be all that would be required to move the piston down. The stem finally seals on the seat *k*. The heads of the spool *j* are now moved out of their seats and permit an unrestricted flow of steam to the compressor. After the stem seals at *k*, the inside spring *l* is compressed and the piston moves down on its stem, sealing the head *m* on the gasket *n*. Thus the seal at *k* prevents steam leakage past the stem and the seal at *n* prevents leakage from the main reservoir.

A further increase in main-reservoir pressure serves to hold the piston and stem more securely in their sealing positions; therefore, as long as the main-reservoir pressure is maintained above 30 pounds, the throttle valve remains in its open position.

Should conditions be such as to cause the main-reservoir pressure to drop to about 20 pounds, the spring *a* will move the piston up and seal the rim on the gasket *d*. The piston, as it moves up, engages the collar *i* on the stem and raises it, thus lifting the heads of the spool into throttling position as shown. The groove *e* is uncovered as soon as the piston seals, and the area of the piston outside of the rim *c* is vented to the atmosphere. This reduces the total area of the piston subject to pressure and causes the spring *l* to seal the rim *c* more securely, thereby preventing leakage past the piston to the vent port *f*.

Thus, when the main-reservoir pressure is being increased, the steam throttle valve throttles the compressor until the pressure reaches 30 pounds but on a reduction of pressure the valve will begin to throttle the compressor at a main-reservoir pressure of about 20 pounds.

In case a pipe leading to the top cover breaks, the steam throttle valve can be held in non-throttling position by removing the locking-cam nut *p* and turning the adjusting screw downward so as to move the piston and spool into non-throttling position. The upward movement is limited by a cross-pin *o* pressed into the lower end of the stop-screw and the downward movement by the large upper threaded portion. This allows sufficient downward travel of the piston and spool valve to move the latter into non-throttling position, but not far enough to have the lower sealing bead on the piston engage the gasket *n*.

M-3-A FEED VALVE AND M-3 REDUCING VALVE

37. Purpose.—The purpose of the M-3-A feed-valve is to regulate the pressure in the brake pipe with the automatic brake valve in running position. The M-3 reducing valve reduces the main-reservoir pressure for independent brake-valve operation and the train air-signal system. Both valves are mounted on the brake-valve pedestal and are identical except that the M-3-A is provided with adjustable stops for double-pressure control.

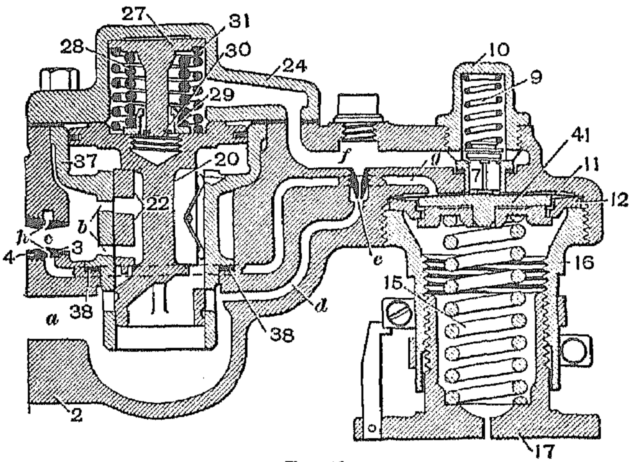


Fig. 19

38. Names of Parts.—The names of the principal parts of the M-3 feed-valve shown in the diagrammatic view, Fig. 19, are as follows: *2*, body; a venturi tube fitting *c* comprising a bushing *3* and a nut *4*; *7*, regulating valve; *9*, regulating-valve spring; *10*, regulating-valve cap nut; *11*, diaphragm (two required); *12*, diaphragm ring; *15*, regulating spring; *16*, regulating-spring box; *17*, regulating nut; *20*, piston, *22*, slide valve; *27*, piston-spring stem; *28*, inner piston spring; *29*, spring collar; *30*, spring-collar retainer; *31*, outer piston spring; *37*, cage bush; *41*, diaphragm follower; and *e*, $\frac{1}{8}$-inch choke plug with $\frac{3}{64}$-inch drill.

39. Open Position.—With the feed-valve in open position, Fig. 19, the air from the main reservoir flows through passage *a*, ports *b*, and the venturi tube *c* to the brake pipe. The air in

passage *a* also enters the passage *d*, passes through the choke *e*, and enters passage *f*, which leads to the outer face of the piston *20* and to the regulating valve *7*. The regulating valve is unseated by the spring *15*, which is set for the brake-pipe pressure desired, when the pressure in the brake pipe is less than standard; hence the air in passage *f* enters passage *g*. From this passage the air passes through the opening *h* between the venturi-tube bushing *3* and the nut *4* to the brake pipe. When the pressure in the brake pipe, in passage *g*, and on the

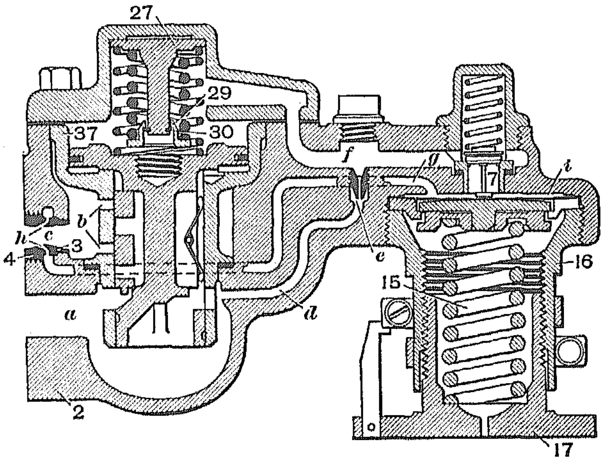


FIG. 20

diaphragm *11* reaches the amount to which the regulating spring is set, the spring *15* is deflected and thereby permits the spring *9* to seat the regulating valve *7*. The pressure continues to increase in passage *d* and in passage *f* until the difference between the pressures on either side of the piston *20* is about equal to the tension of the springs *28* and *31*. When this occurs, these springs force the piston and the slide valve *22* to closed position as shown in Fig. 20.

40. Closed Position.—In closed position of the feed-valve, Fig. 20, air at main-reservoir pressure is in passages *a*, *d*, and *f* and air at brake-pipe pressure is in passage *g*. A decrease in this latter pressure will permit the spring *15* to expand and thereby unseat the regulating valve *7*. The air in passage *f*

immediately reduces to brake-pipe pressure, and the greater main reservoir pressure below the piston will at once force it upward. With the slide valve drawn to open position as in Fig. 19, the brake pipe will again begin to charge.

41. Venturi Tube.—The purpose of the venturi tube is to prevent any tendency of the feed-valve to close at intervals before the pressure in the brake pipe reaches standard pressure. It might be possible, without this tube, that the main-reservoir air might build up in pasages *f* and *g*, Fig. 19, and compress the regulating spring *15*, thereby closing the regulating valve *7* before the pressure in the brake pipe had reached standard pressure. This would cause an interruption in the flow of air to the brake pipe until the pressure in passage *g* has reduced below the setting of the regulating spring.

The manner in which the venturi tube obtains an uninterrupted or a sustained flow of air from the main reservoir to the brake pipe is as follows: The main reservoir air in flowing through the venturi tube to the lower pressure in the brake pipe develops an increased velocity at the small section of the venturi tube with a corresponding decrease in pressure at this point. Passage *g* leads into the venturi tube at this small section, or throat, so that the pressure in the diaphragm chamber will remain about equal to the pressure in the brake pipe. This condition permits the regulating spring *15* to open the regulating valve *7* more fully, thus allowing a greater flow of air with a consequent greater reduction of pressure on the face of the supply piston *20*. Therefore, any building up of pressure on the diaphragm *11* that would result in a premature closing of the feed-valve is prevented. As the pressure in the brake pipe nears standard, the velocity of the air through the venturi tube and passage *g* decreases. Therefore, the effect of the tube in reducing the pressure in the diaphragm chamber becomes less, thus permitting an accumulation of pressure in this chamber which tends to close the regulating valve at its true setting. The choke *e* restricts the flow of air to passage *f* to less than what can be taken away by the regulating valve and passage *g*, thus permitting piston *20* to open the slide valve *22* promptly.

TYPE AD SUPER GOVERNOR

42. Description.—An exterior view of the type AD super governor is given in Fig. 21 and a sectional view is shown in Fig. 22. The purpose of the super governor, which is designed to function with high-temperature steam, is to restrict sufficiently the speed of the air compressor when the desired main-

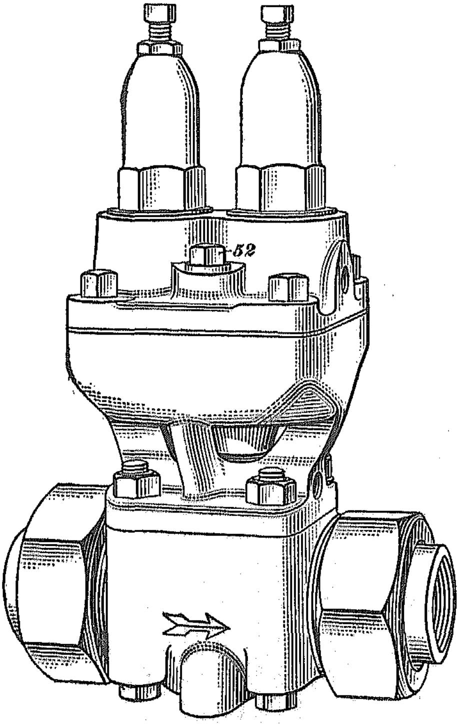


Fig. 21

reservoir pressure is obtained, thereby preventing the rise of this air pressure beyond a certain predetermined point.

The piston body *3* is bolted to the steam-valve body *2* so that the main steam-line unions do not have to be loosened when making repairs to the operating parts. The upper and lower portions of the piston body are connected by ribs; this arrangement insulates to a great extent the piston and the operating

parts above it from the intense heat of the steam portion. A sheet-metal dust excluder *47* prevents dirt from entering between the ribs into the piston chamber. The stem of the

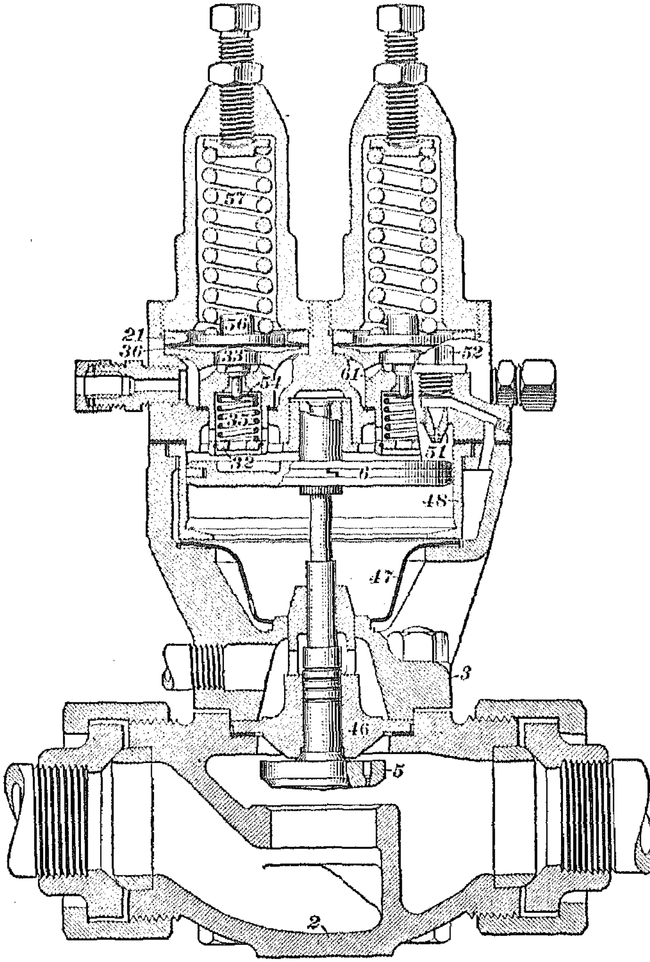


FIG. 22

piston *6* operates within a hole drilled to receive it in the steam valve.

The tubular stem of the steam valve is grooved externally, as shown, to resist leakage of steam or oil along the stem with

the valve between the upper and lower seats. Any leakage that does occur is vented to the atmosphere through the ports in the steam-valve bushing *46* and the vent shown.

In the regulating top the diaphragm ring is indicated by *21*, the diaphragm by *36*, and the regulating-spring seat by *56*. Each diaphragm valve *33* is normally held in contact with its seat *61* by the tension exerted by the regulating spring *57* on the regulating-spring seat. When the air pressure under one of the diaphragms overcomes the tension of the regulating spring, the diaphragm valve is moved upward and unseated by the diaphragm-valve spring *35*.

The spring rests on a spring seat *32* and the diaphragm-spring retainer *54* is interposed between the spring and the valve. The regulating top is secured to the piston body by four capscrews. The low-pressure cap is connected to the automatic brake valve by the low-pressure operating pipe and main-reservoir air passes through the brake valve to this pipe in full release and running positions. The high-pressure top is piped directly to the main reservoir.

43. Operation.—Let it be assumed that the automatic brake valve is in either full release or running position. When the main-reservoir pressure in the low pressure operating pipe and in the chamber below the diaphragm *36*, Fig. 22, plus the upward force exerted by the spring *35* against the diaphragm valve *33* becomes slightly greater than the downward pressure of spring *57*, the diaphragm and also the diaphragm valve will be raised, thus unseating the latter and allowing air to flow down above piston *6*. The steam valve then seats and shuts off the passage of steam to the compressor with the exception of what passes through the small port in the valve. This steam causes the compressor to make an occasional stroke.

When the pressure in the main reservoir and below the diaphragm falls below the tension of the regulating spring, the diaphragm valve seats. The air above the piston discharges through choke plug *51*, the annular space surrounding the bushing *48*, the clearance space between the bushing and the dust excluder and through a vent port in the latter. The steam valve

will then open. The venting of the air to the atmosphere by way of the annular space just mentioned has a cooling effect on the piston body. The choke plug cap nut *52* is provided to permit the ⅛-inch opening in the choke to be cleaned out.

With the brake valve in either first service, lap, service or emergency position, the flow of air through the brake valve to the low-pressure operating pipe does not occur. Hence the main-reservoir air that is always present in the high-pressure operating pipe will cause the high-pressure head of the governor

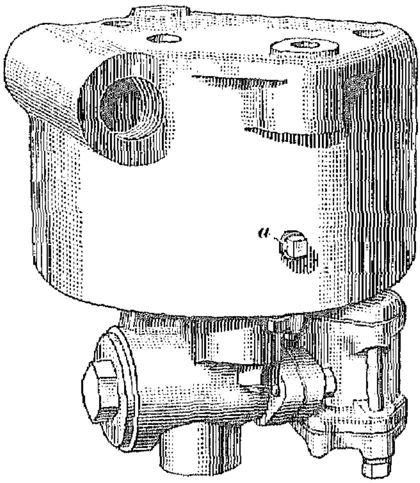


Fig. 23

to operate and stop the compressor when the pressure in the main reservoir reaches the adjustment of this head.

The arrangement for a high and a low-pressure permits the compressor to operate while the brakes are released against a comparatively low main-reservoir pressure, which is, however, ample to keep the system properly charged and supply any leakage. The only time the compressor has to operate against the maximum main-reservoir pressure is during the time the brakes are applied, which relieves the compressor of an unnecessary burden of work and at the same time provides for a high main-reservoir pressure to insure a prompt release and recharge of the brakes.

BRAKE-PIPE VENT VALVE

44. Purpose.—The purpose of the brake-pipe vent valve is to discharge brake-pipe air to the atmosphere when the brake valve is placed in emergency position, thereby increasing the reduction made at the brake valve sufficiently to insure that quick action is started by the triple valves in the train.

45. Operation.—An exterior view of the No. 4B brake-pipe vent valve is given in Fig. 23 and a diagrammatic view of

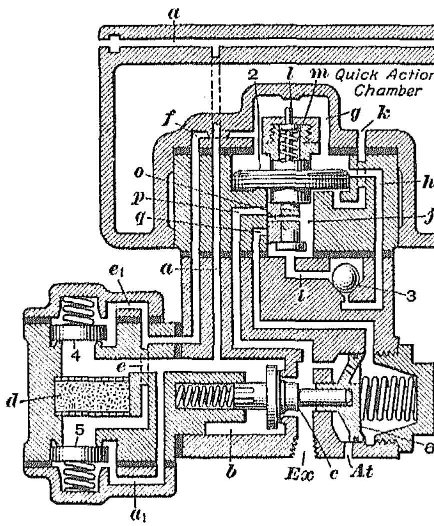


FIG. 24

the valve in normal position is given in Fig. 24. Air from the brake pipe enters passage *a* and flows to chamber *b* at the left of the quick-action valve *c*. From chamber *b* the air flows downward through the strainer *d*, and thence through passages *e* and *f* to chamber *g* above the emergency piston *2*, which is forced to its lower position. In this position the charging port *h* is opened so that brake-pipe air flows past the ball check-valve *3* and through passage *i* to the slide-valve chamber *j* and thence through passage *k* to the quick-action chamber which charges to brake-pipe pressure. The release check-valve *4* is

held to its seat by its spring unless the strainer is so dirty as to cause a difference in pressures of 2 pounds on its upper and lower faces. Under this condition the resistance of the spring will be overcome and the release check-valve will unseat and allow the air to flow to passages e_1, and f directly, thus by-passing the strainer.

46. During a service reduction in brake-pipe pressure, the air flows from the piston chamber g, Fig. 25, through the passages f and e, then upward through the strainer d and thence

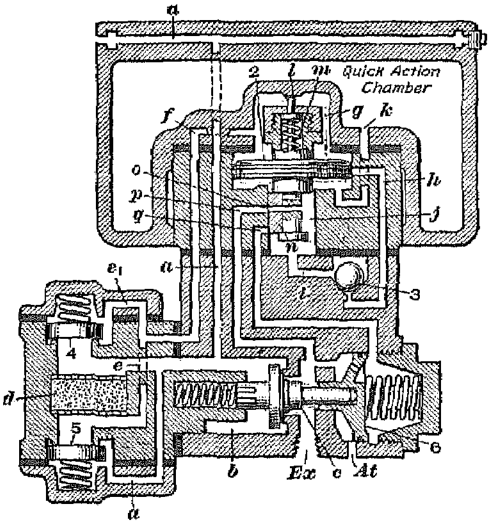


FIG. 25

through passage a to the brake pipe. However, should the restriction at the strainer due to dirt exceed the 2-pound value of the spring under the application check-valve 5 the valve will unseat and permit the air to flow back to the brake pipe through passage a.

The unbalancing of the pressures on the emergency piston 2 causes the higher pressure in chamber j to move it upward until the piston stop l strikes the cap where the further travel of the piston is prevented by spring m. The charging port h is now closed and the slide valve n, which was carried upward with the piston, brings port o in register with port p, and the

quick-action chamber air begins to vent to the exhaust, *Ex*. The pressure in the quick-action chamber does not reduce at quite the same rate as the brake-pipe pressure but reduces somewhat faster, with the result that the piston moves the slide valve down and brings ports *o* and *p* out of register. As the reduction continues in the brake pipe, the ports will be opened again; hence during a service reduction there will be an intermittent exhaust or "spitting" of air at the exhaust port. After the reduction in brake-pipe pressure stops, port *o* in the slide valve will move

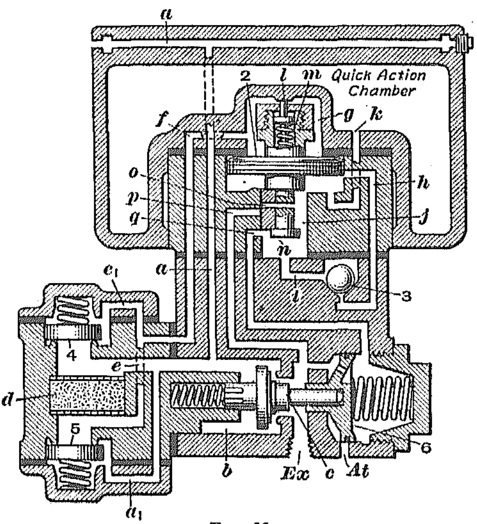


FIG. 26

definitely out of register with port *p*, and will remain in this position until either another reduction is made or until the brakes are released. The ball check *3* prevents any back flow of air from the quick-action chamber to the brake pipe while the emergency piston is moving to service position.

During service reductions there is not enough difference in pressures on the emergency piston *2* to cause it to move beyond service position, provided the vent valve is in good condition.

47. An emergency rate of brake-pipe reduction causes a sudden drop in pressure in chamber *g*, Fig 26. The higher pressure in chamber *j* and in the quick-action chamber forces

the emergency piston upward; hence the spring *m* is compressed and the slide valve *n* is carried to the limit of its travel. In this position port *q* is uncovered, so that air from the quick-action chamber will flow through this passage to the outer face of the quick-action piston *6* and force it to the left, thereby unseating the quick-action valve *c*. The air in the brake pipe now discharges by way of passage *a* and chamber *b* to the atmosphere and the rapid venting of brake-pipe air propagates quick action to adjacent cars.

The air in the quick-action chamber reduces through the small vent port shown in the quick-action piston until the piston spring is able to force the valve and the piston to their normal positions. With the outlet to the atmosphere closed, the brake pipe and the quick-action chamber can be recharged when desired, as already explained.

48. **Disorders.**—If the vent valve causes an emergency application following the movement of the brake valve from release to running position when releasing the brakes, the trouble is caused by the partial obstruction of either port *o* or port *p*, Fig. 25. In full release position, the quick-action chamber as well as the brake pipe on the front end of the train charges higher at first than the rear end. When the brake valve is moved to running position, the brake-pipe air flows toward the rear of the train, and hence causes the pressure to lower on the front end. The emergency piston then moves out and as the air behind it cannot escape rapidly enough through the partly blocked ports, the piston is forced to emergency position. A test to determine whether a vent valve will cause undesired emergency is to make a continuous service reduction of 20 pounds with the engine alone from maximum brake-pipe pressure. If the vent valve does not move to emergency position under these conditions, it will not cause undesired quick action when coupled to a train. If necessary the vent valve can be cut out by plugging the exhaust opening.

A continuous blow at the exhaust opening of the vent valve indicates a leak past the rubber-seated quick-action valve *c* or a leaky emergency slide valve *n*, Fig. 25. To determine

which is defective, remove the plug *a*, Fig. 23, from the quick-action chamber, and if the blow at the exhaust continues, the quick-action valve leaks. If the blow stops, the slide valve leaks.

49. Significance of Color.—In order to make the operation of this brake equipment more readily understood, the charts that accompany this lesson paper are printed in two colors, red and green. These colors are used to make it easy to identify the passages and ports named in the description of the operation of the equipment. Thus in Plate 1, Release Position, all of the ports and passages referred to in the explanation of this position are indicated by color. Ports and passages that contain air under pressure are indicated by red; those with air at atmospheric pressure are shown in green.

The fact that certain ports and passages are not shown in color is not an indication that they do not contain air under pressure; rather it means that the air in such places is not directly concerned with the particular phase of operation that is being described, hence color is unnecessary.

AUTOMATIC BRAKE OPERATION

FULL RELEASE AND CHARGING POSITION

50. Flow of Air Through Brake Valve.—Full release position is used when it is desired to charge the brake system quickly and to release the brakes on long trains. With the handle of the automatic brake valve in full release position, Plate 1, the air from the main reservoirs flows through the main-reservoir pipe and the air filter to passage *7* in the brake valve, thence through passage *7c* to the upper outer area of the charging valve *106*. As the under side of this valve is connected through passage *13* and port *r* in the rotary valve to the exhaust port *Ex*, the charging valve is forced down from its seal by the main-reservoir air, which then flows through passage *7e* to the chamber *A* above the rotary valve. The main-reservoir air, in passing upward through passage *7*, also flows through passage *7b* to the M-3-A feed-valve, where it is reduced to brake-pipe pressure and discharged through passage *20*, and a choke to chamber *A* above the rotary valve. The air in chamber *A* now passes

through port *E* in the rotary valve and passages *1a* and *1*, to the brake pipe and through passages *1* and *1b*, to the chamber beneath the equalizing piston *126*. Also, the air from chamber *A* flows through port *s* in the rotary valve and passage *5* in its seat to the equalizing reservoir and through passage *5a* to the chamber above the equalizing piston *126*.

The main-reservoir air in passage *7* in the brake valve flows through cavity *e* in the rotary valve to the passage marked *Gov.*, the effect of which is to cause the compressor to stop when the main-reservoir pressure becomes greater than that at which the governor is set.

The reduction limiting reservoir is connected through passage *22*, cut-out cock *80*, and cavity *F* in the rotary valve to the brake-valve exhaust *Ex*.

Air at main-reservoir pressure enters the reducing valve through passage *7d* and is discharged at a pressure of 45 pounds to passage *14b*, from whence the air flows through passage *14* to chamber *X* above the independent rotary valve *154*. Air from the reducing valve also flows through passage *14a*, strainer *52*, past check-valve *53* and through port *15a* and choke *33* to the signal pipe *15*.

A port in the charging valve *106* allows a small volume of main-reservoir air from passage *7c* to pass to the under side of the piston, thence through passage *13* and port *r* in the rotary valve to the exhaust port *Ex*. The noise of the escaping air serves to attract the attention of the engineman to the position of the brake-valve handle, warning him that the brake pipe will be overcharged if left in full release position too long.

51. Charging Distributing Valve.—The air from the main-reservoir pipe flows through the air-filter, Plate 1, and passage *7* in the distributing valve, to chamber *M* and through choke *36* to chamber *M1* and the spring side of the application valve *37* and pilot valve *40*. The main-reservoir air in passage *7* also flows through passage *7a* to the slide-valve chamber of the delay valve.

Air from the brake pipe flows through a dirt collector in the branch pipe to the distributing valve, thence through passage *1*,

and the curled-hair strainer *32*, to chamber *B* on the face of the equalizing piston *10*, causing the piston and its slide valve to move to the left. The movement of the piston in the absence of air pressure on the other side, compresses the retarded recharge spring *13* in the end of the equalizing piston, and this piston will move back to retarded recharge position, where its inner face will contact with seal *26*. If the retarded recharge cock *70* is in the *F*, or closed, position as shown, the air will then flow through the feed-groove *v*, the charging choke *4*, and passage *a* to the slide-valve chamber *F*, and thence through passage *1d* to the pressure chamber. When the pressure in the pressure chamber and in the slide-valve chamber *F* builds up to within a few pounds of standard brake-pipe pressure, the retarded recharge spring *13* will move the piston to the right as shown in Plate 2. In this position the charging of the pressure chamber is not restricted by choke *4* but is controlled by the feed-groove *v*.

With the retarded recharge cock *70* in *P*, or open, position, air from the brake pipe charges the slide-valve chamber and the pressure chamber through choke *4*, as already explained, and in addition through passage *V2*, cock *70*, passage *a*, and choke *68*. Thus in retarded recharge position of the equalizing piston, a higher rate of recharge is provided for passenger-train service.

52. Seal 26 and Choke 4.—The purpose of seal 26, Plate 1, and choke *4* is to limit with freight trains, the rate at which the pressure chamber charges during the initial charging of the brake system, and during the time the brake is being released, thus preventing an overcharge of the pressure chamber. However, after the charging or recharging has been completed the seal is broken; the feed-groove then becomes of sufficient size to provide stability against undesired brake applications owing to moderate fluctuations of brake-pipe pressure.

53. By-Pass Check-Valve 5a.—It will be noted that passage *1b*, Plate 1, connects the interior of the strainer *32* to the space between the check-valves *5* and *5a*. Now if during the recharging of the pressure chamber, the strainer *32* should be clogged with dirt to such an extent as to create a difference in pressure

of 2 pounds between its outside and inside surfaces, the higher brake-pipe pressure in passage *1f* on the right-hand side of valve *5a* will unseat the valve against the lesser pressure in passage *1b* on the other side. Air from the brake pipe then passes to the face of the equalizing piston through passage *1b*, thereby by-passing the strainer.

54: **Controlled-Emergency Valve.**—As shown on Plate 1, the controlled-emergency cock is in non-control position, in which the controlled-emergency pipe and the upper side of the controlled-emergency valve piston *161* are vented to the atmosphere through the cock on the independent brake valve bracket. The main-reservoir pressure in the slide-valve chamber under the piston then holds it up in non-control position.

RUNNING POSITION

55. **Flow of Air Through Brake Valve.**—Running position of the brake valve is used, when running along the road, to maintain a predetermined brake-pipe pressure lower than that carried in the main reservoirs, to release the locomotive brake, and also to release the brakes on short trains. If the brake valve were allowed to remain too long in release position, the brake system would be charged to main-reservoir pressure. To avoid this, the brake-valve handle must be moved after the proper interval to running position, in which position the pressure in the brake pipe cannot attain a pressure above that for which the feed-valve is adjusted.

In running position passage *13*, Plate 2, is no longer connected to the exhaust port *Ex*, but is blanked by the rotary valve, with the result that main-reservoir air from passage *7c* passes through the small hole in the charging valve *106* until the pressures are about equal on both the upper and the lower faces. The spring *111* then forces the valve to its upper seat and so prevents the further flow of main-reservoir air through passages *7c* and *7e* to chamber *A*. Therefore, only the feed-valve supplies air by the way of passage *20* to chamber *A* above the rotary valve and, as this occurs in all positions of the brake valve except full release, the handle of the brake valve is easy to move.

From chamber *A* the air passes through port *E* and passage *1a* and *1* to the brake pipe, through port *E* and passage *19* and *19a* to the maintaining valve *132* and through port *s* and passages *5a* and *5* to chamber D and the equalizing reservoir. As in release position, a branch passage *1b* from the brake-pipe passage *1*, permits the charging of chamber *N* beneath the equalizing piston, so that chambers *D* and *N* and the equalizing reservoir charge uniformly with the brake pipe. As a result the equalizing piston and its attached lever *136* will remain in a balanced position where the spring *134a* holds the discharge valve *129* seated. Thus the brake-pipe air in chamber *N* is prevented from escaping through the exhaust passage *1d* to the atmosphere at *At.* in the top case of the brake valve by the discharge valve *129* and by the exhaust valve *97* as well.

Passage *7* which contains air at main-reservoir pressure, is connected through cavity *e* in the rotary valve to the passage marked *Gov.*, so that main-reservoir air flows to the low-pressure head of the governor.

The reduction limiting reservoir is open to the atmosphere through passage *22*, cock *80*, cavity *F* in the rotary valve, and exhaust port *Ex.*, as well as through choke *120.*

56. Flow of Air Through Distributing Valve.—At the distributing valve, the slide-valve chamber *F*, Plate 2, and the pressure chamber charge from the brake pipe through the feed-groove *v* because the equalizing piston has been moved away from its seal *26* by the retarded recharge spring *13.*

The application cylinder is connected through passage *12d*, a cavity in the controlled-emergency slide valve *163*, passage *12b*, a cavity in the reduction chamber cut-off slide valve *101*, passage *12a*, choke *127*, and passage *12* to the application pipe. The application chamber is connected through passage *11*, cavity *b5* in the equalizing slide valve to passage *12b*, and thence to the application pipe as just described. As both brake valves are in running position, the application pipe is connected through passage *12* in the brake-valve pedestal, ports *v* and *p*, in the rotary valve *154*, passage *3*, and cavity *F* in the automatic rotary valve to the exhaust *Ex.* With both the applica-

tion chamber and the application cylinder open to the atmosphere through the application pipe, the application piston *23* in the distributing valve will be in release position, in which the exhaust slide valve *25* will connect the brake cylinders through passages *9*, *9a*, *9b*, and *9c*, the slide valve chamber *C*, and the ports in the slide-valve seat to the atmosphere at *Ex*.

The reduction chamber is connected by way of passage *8a*, cavity *c* in the equalizing slide valve and port *At.* in its seat to the atmosphere. It will be noted that chamber *S* on the spring side of the reduction chamber cut-off piston *98* is connected by way of passage *19*, port *b2*, passage *b*, port *b1* and passage *18a*, to the other side, so that the spring *106* will hold the valve in the position shown.

Chamber *E* on the face of the release piston *87* is connected through passage *6*, the independent release pipe, passage *6* in the brake-valve pedestal, ports *w* and *z* in the independent brake-valve rotary valve to the exhaust port *Ex*.

AUTOMATIC SERVICE POSITION

57. Flow of Air Through Brake Valve.—Service position is used when it is desired to make a service application of the brakes. In this position of the brake-valve handle, the pawl *96*, Plate 3, which is actuated by a cam on the rotary-valve key, forces the exhaust valve *97* from its seat and opens passage *1d* to the atmosphere at *At*. In service position, port *f* in the rotary valve *112* registers with passage *5* in the valve seat; this permits the air in chamber *D* above the equalizing piston *126* as well as from the equalizing reservoir to begin to discharge to the atmosphere at *Ex*. The higher pressure in the brake pipe beneath the piston causes it to move upward and rotate the lever *136* around its fulcrum pin, thereby causing the short end of the lever to compress the spring *134a* and unseat the discharge valve *129*. Brake-pipe air from chamber *N* then escapes past the unseated discharge valve to passage *1d*, which is open to the atmosphere by way of the exhaust valve *97*, as already explained.

When the pressure in the equalizing reservoir and in chamber *D* has been reduced the desired amount, the handle of the brake valve is moved to lap position as shown in Plate 4, thus stopping

any further reduction. The exhaust valve *97* is still held open in lap position so that air continues to discharge from the brake pipe until the pressure has fallen slightly below that retained in chamber *D*. The equalizing piston then moves down, the short end of the lever *136* rotates to the right, and the spring *134a* closes the discharge valve *129*. Thus the amount of the reduction in the equalizing reservoir determines that in the brake pipe regardless of the length of the train.

The downward movement of the piston is influenced by the rate at which the brake-pipe pressure is reduced, so that the discharge valve will close more slowly with a long train than with a short one. The gradual stopping of the discharge, which is further assisted by the choke in passage *1d*, is to prevent the brake-pipe pressure at the head end of the train from being built up by the air flowing from the rear, which action might cause some of the head brakes to kick off.

In service position the passage in the brake valve that leads to the low-pressure governor is covered by the rotary valve, so that the high-pressure governor will now control the compressor.

58. Operation of Distributing Valve.—The reduction in brake-pipe pressure produced by the brake valve results immediately in a decrease in the pressure in chamber *B*, Plate 3, on the face of the equalizing piston *10* because this chamber is connected by way of passage *1a*, the strainer *32*, and passage *1* to the brake pipe. The greater pressure in chamber *F* on the inside face of the piston then moves it to the right. On the first movement of the piston the feed-groove is closed and the graduating valve is moved to uncover port *f* in the equalizing slide valve *18*; next, the shoulder on the piston stem engages the equalizing slide valve and moves it to service position. The movement of the piston is finally arrested by coming in contact with the graduating stem *28*, which is prevented from yielding by the graduating spring *31*.

With the equalizing slide valve in service position, Plate 3A, the air in chamber *F* and in the pressure chamber flows through port *f* in the valve to passage *12c* in the seat, thence through

a cavity in the reduction chamber cut-off slide valve *101* and passage *8a* to the reduction chamber, and also through a branch from passage *8a*, a cavity *c* in the equalizing slide valve, and passage *18a* to the slide-valve chamber *K* of the reduction chamber cut-off piston *98*. Passage *19* on the left of the piston is now connected through port *d1* in the equalizing slide valve to the exhaust port *At*, so that there is spring pressure only acting on the left of the piston *98*. When the pressure in the reduction chamber and in chamber *K* on the slide-valve side of piston *98* is built up to 30 pounds, which pressure is developed by a brake-pipe reduction of 4½ pounds, the force exerted by the spring *106* is overcome by the air pressure on the other side of the piston and it and its slide valve are moved to the left; the cut-off piston then contacts with its seal as shown in Plate 3. The cut-off piston is now held in cut-off position by pressure-chamber air supplied through passage *13*.

The slide valve *101* now blanks passage *8a* to the reduction chamber and connects passages *12c* and *12b*, permitting air from the pressure chamber to flow through port *f*, passage *12c*, and the cavity in the cut-off slide valve *101* to passage *12b*. After leaving the vertical passage *12b*, the air from the pressure chamber passes to the left into the horizontal passage *12b*, thence through the lower cavity in the controlled-emergency slide valve *163* to passage *12d* and to the application cylinder *A* on the face of the application piston *23*. Also, pressure-chamber air in the vertical passage *12b* flows to the right through passage *12b*, then through cavity *b5* in the equalizing slide valve and passage *11* to the application chamber. A branch passage *12h* from the vertical passage *12b* conveys application cylinder and application chamber air to the left of the cut-off check-valve *96*, which prevents the air from passing into port *12e* and the application pipe *12*. The reduction-chamber cut-off valve also disconnects port *12b* from port *12a* and so prevents the flow of application-chamber and cylinder air from passage *12b* to passage *12a* and the application pipe. Thus the application cylinder is cut off in two ways from the application pipe. Hence, there is no connection between the application chamber and cylinder and the application pipe in automatic service.

59. The piston *23*, with the attached exhaust slide valve *25*, is moved to the right by the development of pressure in chamber *A*, and closes first the two brake-cylinder exhaust ports in the slide-valve seat. As the piston continues to move, the end of its stem comes in contact with the application pilot valve *40* and forces it from its seat. Main-reservoir air in chamber *M1* now flows to the slide-valve chamber *c*, thence through passages *9c*, *9a*, and *9* to the brake cylinders, and through passage *9b* and choke *3* to the right of the application piston and so steadies its movement. With the pilot valve unseated and the valve *37* seated, the pressure is reduced in chamber *M1* faster than it can be restored from the main reservoir through choke *36*.

The pressure in the interior of the application valve is then reduced so that the pressure with which it is being held to its seat is lessened, hence the valve will be unseated by a slight excess in application-cylinder pressure in chamber *A* over the brake-cylinder pressure on the other side of the piston. With the application valve unseated, the main-reservoir air in chamber *M* is free to flow through an opening of a large capacity and thus with a very light difference in pressures across the application piston, an adequate rate of brake-cylinder build-up is provided for the large brake-cylinder volume used on modern locomotives.

60. In service position, application chamber air in port *11* in the equalizing slide-valve seat passes up through passage *b3* in the equalizing slide valve, thence through cavity *P* in the graduating valve *16*, port *g* in the slide valve, and passage *10* to the safety valve, thus preventing the development of pressure in the locomotive brake cylinders in excess of 68 pounds. The brake-pipe pressure can be reduced and the locomotive brake applied harder until the pressure in the pressure chamber equalizes with the pressure in the application chamber and cylinder. The volume of these chambers in combination with the volume of the reduction chamber is such that a reduction in pressure of 20 pounds from a brake-pipe pressure of 70 pounds causes the pressure in the pressure chamber to equalize with the pressure in the appli-

cation chamber and cylinder at 50 pounds, which corresponds to the brake-cylinder pressure developed on a car on which the piston in the brake cylinder has an 8-inch travel.

61. Charging Application Pipe.—From passage *9c*, Plate 3, the brake-cylinder air flows to the right through passage *9* to and through strainer *48*, unseats the check-valve *47*, and continues by way of passage *12f* and the choke *34* to passage *12* and the application pipe, charging it to approximately brake-cylinder pressure. The reason for the admission of air to this pipe is to prevent a sudden drop in application-cylinder pressure and likewise in brake-cylinder pressure, which otherwise would occur should the charged application cylinder be connected to the uncharged application pipe, particularly if this pipe were long.

The admission of brake-cylinder air to the application pipe causes a steady blow at the exhaust port of the automatic brake valve when this engine is in helper service; this serves as an indication that the brake is applied on this locomotive.

The brake-cylinder pressure will not be affected because the leakage of air is restricted to the capacity of choke *34* and can be more than compensated for by the flow from the main reservoirs to the brake cylinders. For the same reason a broken application pipe will not affect the brake-cylinder pressure.

62. Reason for Flow of Air to Reduction Chamber.—The reason for permitting the air to flow at first from the pressure chamber to the reduction chamber is to cause the braking force on the locomotive to develop at about the same rate as on the cars, thereby contributing to smoother handling. On locomotives equipped with the ordinary type of distributing valve, the arrangement of the application portion results in a brake-cylinder pressure of about $2\frac{1}{2}$ pounds for each pound of brake-pipe reduction, whereas on cars the brake-cylinder pressure on an initial reduction increases at a much slower rate owing to the air required to move the brake-cylinder pistons and fill the brake cylinders. The volume and cut-off pressure for the reduction chamber are such that an initial reduction of 7 pounds will develop a brake-cylinder pressure on the locomotive, of the

same amount instead of $17\frac{1}{2}$ pounds as with the ordinary type of distributing valve, and a pressure of 7 pounds corresponds in time and value to that obtained in the brake cylinders of the train brakes. As already pointed out, the first 4 pounds of the brake-pipe reduction develops no brake-cylinder pressure on the locomotive, the remaining 3 pounds of the reduction, alone, being effective for the development of pressure. Hence, during the first stage of an automatic brake application the development of the braking force on the locomotive corresponds closely in time and pressure to that on the cars.

63. By-Pass Check-Valve 5.—Let it be assumed when reducing the brake-pipe pressure in passage *1* and its branch passage *1f*, Plate 3, that the strainer *32* is clogged with dirt to such an extent as to cause the pressure on the outside of it to be *2* pounds less than the pressure on the inside. In this event the air in chamber *B* in the interior of the strainer and in passage *1b*, will unseat the check-valve *5* against the tension of its spring and the lower air pressure in passage *1f*, and will flow from this passage to the brake pipe, thus by-passing the strainer.

SERVICE LAP POSITION

64. Following a brake-pipe reduction of the desired amount the brake valve is moved to lap position, the purpose of which is to hold the brakes applied after an automatic application. The rotary valve covers all ports in its seat, the equalizing piston moves down, and the discharge valve *129* seats, thereby preventing the further discharge of air from the equalizing reservoir. However, the exhaust valve *97*, Plate 4, is still open as in service position. Provided the reduction has not been sufficient to cause the pressure in the brake pipe to equalize with the pressure in the pressure chamber, the air will continue to flow from the pressure chamber to the application cylinder and the application chamber until the pressure in the pressure chamber is slightly below the pressure in the brake pipe. The pressure in the brake pipe on the right of the equalizing piston *10* being higher than the pressure-chamber pressure on the left side, the piston and the graduating

valve will be carried to the left until the shoulder on the piston comes in contact with the equalizing slide valve, Plate 4. The piston then stops because the slight difference between the pressures on the piston is not enough to overcome the friction of the slide valve on its seat; the valve then remains in service position. This portion of the distributing valve is now in lap position, in which the graduating valve *16* covers port *f* in the slide valve, thereby cutting off the further flow of air from the pressure chamber to the application chamber and cylinder. Also, the graduating valve breaks the connection between passage *f* and passage *g* in the equalizing slide valve, and hence between the application chamber and cylinder and the safety valve, so that any leak at the safety valve cannot reduce the pressure in the application cylinder and consequently in the brake cylinder.

65. After the equalizing piston and the graduating valve move to lap position, the application piston *23* will shortly after assume its lap position. The flow of main-reservoir air past the application valve *37* to the brake cylinders continues until the pressure on the right of the application piston *23* slightly exceeds the pressure in the application cylinder on the left of the piston. The piston then moves to the left and the springs *44* and *45* close the application valve *37* and the pilot valve *40* and so prevent the further flow of air to the brake cylinders. The piston *23* stops after its collar comes in contact with the exhaust slide valve *25* because the pressure on the right side of the piston is not enough higher than the pressure on the left side to overcome the friction of the slide valve on its seat, so that this valve will still cover the exhaust port *Ex*. With the air pressures on the piston practically balanced, any reduction in brake-cylinder pressure due to leakage will cause the pressure in chamber *A* to move the piston *23* to the right and open either the pilot valve or the application valve far enough to restore the brake-cylinder pressure to approximately that in the application cylinder. The piston will then again move to lap position. The maintenance of brake-cylinder pressure at the original pressure at which the brake was set, constitutes what is known as the pressure-maintaining feature.

RELEASE AND RECHARGE

66. The operation of the equipment when applying the brakes has been explained in the foregoing; next it will be shown how the equipment operates to obtain a release of the brakes. The brakes on the train are released by placing the brake valve in either release or running position but the brake on the locomotive releases only in running position. With the locomotive brake held on in release position, the locomotive is held back against the train, thus preventing shocks, during a release of the train brakes.

The flow of air through the automatic brake valve has already been explained, so this phase of operation does not have to be repeated. The increase in brake-pipe pressure that follows the movement of the automatic brake valve to release position, raises the pressure on the equalizing piston *10* of the distributing valve, Plate 1, above the pressure-chamber pressure on the other side. The piston then moves to the left, carrying with it the slide valve and the graduating valve, and makes a joint against the seal *26* and also compresses the retarded recharge spring *13*. Air now flows through the feed-groove *v* and the charging choke *4* to the pressure chamber until the pressure in this chamber is increased to slightly less than the brake-pipe pressure. When this occurs the piston will be moved to the right by the force of the retarded recharge spring *13*, thereby breaking the contact between the piston and the seal; the pressure chamber will then charge to brake-pipe pressure through the feed-groove *v*.

67. As soon as the equalizing slide valve moves to release position the air in the chamber that houses the cut-off slide valve *101*, which is still in application position, flows through passage *13*, through the ports *b* and *b2* in the equalizing slide valve to passage *19*, and to the spring side of cut-off piston *98*. With an approximate balance of pressures on the piston *98*, the spring *106* moves the piston, and the cut-off slide valve to the right port *13* now closes and port *18a* opens. Both sides of piston *98* are now connected through passage *b4* and cavity *b5* in the equalizing slide valve, passage *12b*, the cavity in the cut-off

slide valve and passage *12a* to the application pipe. With the cut-off slide valve to the right, air from application chamber flows through passage *11*, cavity *b5* in the equalizing slide valve, thence downward through passage *12b* and through a cavity in the cut-off slide valve *101* to passage *12a* and to the application pipe. The application cylinder *A* is also connected through passage *12d* and a cavity in the controlled-emergency slide valve to passage *12b*, which is connected to passage *12a* and the application pipe as already explained. The application pipe, with the brake-valve handle in release position, is connected through passage *12* in the pedestal, ports *v* and *p* in the independent rotary valve, passage *3*, and port *R* in the automatic rotary valve to passage *3a* in the seat, which passage is closed by plug *A*. As the discharge of the air from the application pipe is prevented, the locomotive brake cannot be released in release position of the automatic brake valve unless plug *A* is removed.

But with the handle of the automatic brake valve in running position, Plate 2, passage *3* is connected through cavity *F* in the rotary valve to the exhaust port *Ex*, thus opening the application pipe to the atmosphere and reducing the pressure in chamber *A* on the left of the application piston *23*. The higher pressure in the brake cylinders on the right of the piston then moves it and the exhaust slide valve *25* to release position and the air from the brake cylinders flows back through pipe and passage *9* and passages *9b* and *9c* to the exhaust slide-valve chamber *c*, which is open to the atmosphere through the exhaust port *Ex*. The locomotive brake then releases. The rate of release in running position is controlled by the choke *127* in passage *12a* and will therefore be the same for any installation regardless of the length of the application pipe. This choke provides a predetermined rate of release of from 45 pounds to zero in 15 seconds.

68. A graduated release can be obtained by moving the handle of the brake valve between running and lap positions, which reduces the pressure in the application cylinder and chamber in steps and results in corresponding reductions of brake-cylinder pressure.

If it is desired to release the locomotive brake in lap position, following a movement of the brake-valve handle to release position, it is only necessary to remove plug *B* from the automatic brake-valve portion. As shown in Plate 4, this opens passage *3*, through the ports *m* and *h* in the rotary valve, to passage *3b* and the atmosphere.

The air in the reduction chamber flows through passage *8a* to the exhaust port *At*. in the equalizing slide-valve seat. The air in the chamber that houses the cut-off slide valve *101* flows through passage *18a* to passage *b2* in the equalizing slide valve, also, the air in the spring chamber of the cut-off piston flows through passage *19* to passage *b2*. This passage is connected through cavity *b5* to passage *12b*, which, as already explained, leads by way of the application pipe to the atmosphere.

FIRST-SERVICE POSITION

69. First-service position is for use with long trains with which the pressure in the brake pipe, on account of leaks and of the resistance offered by the long brake pipe to the flow of air, is usually progressively lower from the front of the train to the rear. With such a condition, the normal service brake-pipe reduction tends to develop the braking force at the head end of the train faster and to a higher value than on the rear, thereby causing slack action.

The reason for the higher braking force at the head end is that in service position the air supply from the feed-valve to the brake pipe is cut off, so that the higher pressure in the front end of the brake pipe will flow toward the rear end. This action in combination with the reduction being made at the brake valve will, unless compensated for, cause a heavy brake application on the front cars. First-service position overcomes this by supplying air to the brake pipe from the feed-valve should leakage cause the brake-pipe pressure to drop faster than the slow rate at which the pressure reduces in the equalizing reservoir. This action causes the brake-pipe pressure to be reduced more uniformly in all parts of the train, thereby accomplishing better control of the train than would otherwise be possible. After an initial reduction of 6 pounds, the brake-pipe reduction

in first-service position occurs more slowly than in service position.

70. When the handle of the brake valve is placed in first-service position, Plate 5, the air from the equalizing reservoir and from the chamber above the equalizing piston *126* flows through passage *5*, next through a restricted port *n* in the rotary valve to passage *m*, and thence through passage *22* to the reduction limiting reservoir. The relation between the volumes of the reduction limiting reservoir and the equalizing reservoir is such as to reduce the pressure in this reservoir at the normal service rate of about 3 pounds per second, until a reduction of about 6 pounds is obtained with a brake-pipe pressure of 70 pounds. Thereafter the reduction continues at a much slower rate through the choked exhaust plug *120*.

The *reduction of about 6 pounds from the equalizing* reservoir at the normal service rate insures the starting of quick service of the train brakes, after which the reduction continues slowly owing to the size of the choke.

As the pressure is reduced from the equalizing-reservoir side of the piston *126*, the piston is raised by the higher brake-pipe pressure beneath it, and carries the long end of the angle lever *136* upward. The short end of the lever then moves to the left, and engages with a collar on the discharge valve *129*, thereby unseating it and allowing brake-pipe air to escape to the atmosphere through passage *1d* and past the exhaust valve *97*. Owing to the slow reduction in the equalizing-reservoir pressure through the plug *120*, the brake-pipe pressure may become slightly lower, in which event the piston *126* will be *moved down and allow the short end of the lever 136 to move* to the right out of contact with the discharge valve *129*. This valve will then be closed by the spring *134a* until the pressure in the equalizing reservoir has again reduced below the pressure in the brake pipe.

71. Should the brake-pipe pressure *owing* to brake-pipe leakage reduce at a faster rate than the controlled rate at which the equalizing-reservoir pressure reduces, piston *126* will move down, first permitting the discharge valve to close and next

causing the lever *136* to contact the maintaining valve *132*, and move it downward from its seat, as shown in the small view. When this happens, air at feed-valve pressure in chamber *A* above the rotary valve will flow through passages *19* and *19a*, and by the valve *132* to the brake pipe. The building up of pressure beneath the equalizing piston in combination with the reduction in pressure that is taking place above this piston will cause it to rise again and permit the maintaining valve to close and the discharge valve to open. Thus the brake-pipe pressure is prevented from reducing at a higher rate than the equalizing-reservoir pressure is being reduced.

The reduction in brake-pipe pressure is then more uniform throughout the train than would otherwise be possible, thereby accomplishing a more uniform control of the braking force and eliminating slack action.

First-service position may be cut out by turning cock *80* to "out" position, which closes passages *19* and *22* to the maintaining valve and to the reduction limiting reservoir, respectively. First-service position may then be used as a lap position because the only active ports have been closed by the cut-out cock. Also, by removing the plug *B* the locomotive brake will be released as in service lap position because passage *12* and the application pipe will then be connected through a cavity in the rotary valve of the independent brake valve to passage *3*, and ports *b* and *d* to the atmosphere.

The distributing valve operates to apply the locomotive brake in the same manner as explained under Automatic Service Position, but the brake applies more slowly.

EMERGENCY POSITION

72. Development of Brake-Cylinder Pressure.—In emergency position, the brake-cylinder pressure on the locomotive can be made to develop either rapidly or slowly. For short trains when a rapid development of brake-cylinder pressure on the locomotive is desired, the handle of the controlled-emergency cock *187*, Plate 7, in the independent brake valve bracket is turned to passenger position. The development of brake-cylinder pressure is then referred to as being non-controlled.

With the handle of the controlled-emergency cock in freight position the build-up of brake-cylinder pressure will occur more slowly or it will be controlled.

The rapid or non-controlled development of brake-cylinder pressure is brought about by permitting the air from the pressure chamber to flow only to the application cylinder. The slow or controlled development of pressure is caused by allowing the air from the pressure chamber to pass through a choke to both the application cylinder and the application chamber.

The operation of the equipment when set for a rapid or a non-controlled increase in brake-cylinder pressure will be explained first.

73. Flow of Air Through Brake Valve.—In emergency position of the automatic brake valve, Plate 6, the brake pipe is connected through passage *1* in the pedestal and passage *1a* in the rotary-valve seat, and passage *F* in the rotary valve to the exhaust port *Ex*, the result being a sudden and heavy discharge of brake-pipe air. The pressure in the equalizing reservoir and in chamber *D* reduces to zero through passages *5a*, *5*, and port *k* in the rotary valve, which also registers with the exhaust port *Ex*.

The air from the brake pipe, in addition to exhausting to the atmosphere by way of the rotary valve as just explained, also vents in another way. Air from the main reservoir flows from passage *7*, through ports *g* and *e* in the rotary valve to passage *21*, and then through passage *21a* to chamber *S* on the face of the relay-valve piston *49*. This piston is then forced to the right and the piston stem engages and unseats the pilot valve *39*, thereby permitting the brake-pipe air on the spring side of the vent valve *36* to escape past the pilot valve to the atmosphere at *Ex*. The air from the interior or from the spring chamber of the vent-valve escapes more rapidly past the pilot valve than it can be supplied through the choked port from chamber *U*, so that the pressure with which the vent valve is held to its seat is reduced. The stem of the relay-valve piston then easily unseats the vent valve, thus providing a large direct exhaust of brake-pipe air from passages *1c*, *1*, and the brake

pipe. A reduction in brake-pipe pressure can be obtained rapidly enough to produce emergency action of the brakes without the relay valve, but when double-heading, the double-heading cock on the second engine is closed and under this condition the relay valve permits the brakes to be applied in emergency from the second engine should the necessity arise for doing so.

The exhaust valve *97* is open in emergency position and, since the equalizing-reservoir pressure has been reduced to zero, the equalizing piston moves upward, unseats the discharge valve *129*, and opens chamber *N* to the atmosphere through passage *1d*.

74. Flow of Air Through Distributing Valve.—With the brake-pipe pressure reduced suddenly in front of the equalizing piston *10*, Plate 6, in the distributing valve, the greater pressure in the slide-valve chamber *F* moves the piston promptly to the right with sufficient force to compress the graduating spring *31* and seat tight against its gasket; the equalizing slide valve *18* and the graduating valve *16* are now in emergency position. In this position the chamber at the left of the reduction chamber cut-off piston *98* is connected through passage *19*, port *d1* and cavity *d* in the equalizing slide valve to the atmosphere at *At*. Also, air from the pressure chamber flows through the rear port and passage *5*, thence upward through a vertical passage *5*, through a port *c1* and a cavity *c* in the equalizing slide valve, to passage *18a* to the right side of piston *98*. The piston and its slide valve *101* are accordingly moved to their extreme positions at the left as shown, in which passage *8a* is blanked by the slide valve, thereby cutting out the reduction chamber and opening passage *13*. This passage supplies air from the pressure chamber to hold the reduction chamber cut-off piston in cut-off position.

With the equalizing slide valve in emergency position and the reduction chamber cut-off valve in cut-off position, the flow of air from the pressure chamber to the application cylinder occurs as follows: Through the passage *5* and a cavity *b5* in the equalizing slide valve to passage *12b*, and also through a port *N* in this slide valve to passage *12c*, thence through a cavity in the

cut-off slide valve to passage *12b*, from which the combined flow of air passes through the lower cavity in the controlled-emergency slide valve *163* to passage *12d* and to the application cylinder *A*.

With the reduction chamber cut off by the blanking of passage *8a*, and with the application chamber cut off by the equalizing slide valve blanking passage *11*, the air from the pressure chamber flows directly to the application cylinder only, so that the two volumes quickly become equalized, at about 65 pounds. As a result of this rapid direct equalization, the application piston *23* is moved promptly to the right and opens the application valve *37* fully, which then produces a fast build-up of brake-cylinder pressure as already described under Automatic Service. The pressure-chamber air, in passing through port *N* to passage *12c*, also flows through a restricted port into passage *10* that leads to the safety valve.

75. The pressure in the application cylinder is further increased by the flow of feed-valve air from chamber *A*, Plate 6, above the rotary valve of the automatic brake valve. The air passages through the maintaining port *E* in the rotary valve, then through a choke to passage *12b* in the seat, thence through passage *12* to the application pipe, and to the distributing valve where it flows through passage *12*, and the passage *12e*, unesats cut-off check-valve *96* and flows through passage *12h* to passage *12b*, which is connected to the application cylinder as already described.

As already mentioned, the rate of flow of air from the feed-valve to the application cylinder is controlled by a choke in passage *12b* in the rotary-valve seat, and the flow from the equalized application cylinder and pressure chamber to the safety valve is controlled by restricted port *10* in the equalizing slide-valve seat. The capacity of these two ports is so proportioned that balanced maximum application-cylinder pressure is constantly maintained.

The brake-cylinder pressure obtained in emergency will vary with the adjustment of the feed-valve and will depend on the relation between feed-valve pressure and the setting of the

safety valve, so that a higher locomotive brake-cylinder pressure will be obtained with the higher brake-pipe pressure used in passenger service.

76. Controlled Development of Brake-Cylinder Pressure. When a slow increase or a controlled build-up of pressure in the locomotive brake cylinders is desired, as with long trains, the handle of the controlled-emergency cock in the cab is turned to freight position. The operation of the equipment when set for a controlled increase in brake-cylinder pressure will now be explained. The delayed development of pressure is brought about by permitting the air from the pressure chamber to flow through a small choke *128*, Plate 6, in the controlled-emergency valve to both the application cylinder and the application chamber.

With the controlled-emergency cock in the independent brake valve bracket in freight position, the vent is closed and main-reservoir air flows through passage *7f*, the controlled-emergency cock, and the control-emergency pipe *17*, to passage *17* of the distributing valve to the spring side of the piston *161*; also, main-reservoir air is connected to the lower side of this piston through passages *7* and *7a*. With equal air pressures on both sides of the piston, the spring *165* will hold the piston and the slide valve in their lower positions as shown in the supplemental view on Plate 6 entitled Controlled-Emergency Valve, Control Position.

In this position of the controlled-emergency slide valve *163* the pressure-chamber air in passage *12b* will flow through choke *128* and passage *12d* to the face of the application piston *23*, and through the upper cavity in the slide valve *163* to passages *11a* and *11* to the application chamber. The controlled build-up of application-cylinder pressure and therefore of brake-cylinder pressure is caused by the slow build-up of pressure through the choke *128* into the combined volume of the application chamber and the application cylinder.

AUTOMATIC RELEASE AFTER EMERGENCY

77. After an emergency application the equalizing piston remains in full emergency position until the brake-pipe pressure is restored; the application piston and the application valve, however, move to lap position as described under Automatic Service Position.

When the automatic brake valve is returned to release position, the supply of main-reservoir air to passages *21* and *21a*, Plate 1, is cut off, and the air in chamber *S* on the face of the relay-valve piston escapes to the atmosphere through the small bleed port shown. The spring *50* then forces the piston to normal position and this allows the springs *42* and *37* to seat the pilot valve *39* and vent valve *36* thereby closing off the brake pipe to the atmosphere. The brake-pipe pressure is then restored as described under Release, and, as the pressure builds up in chamber *B* on the face of the equalizing piston, it is forced to release position. In non-control position of the controlled-emergency valve, the application chamber is cut off from the application cylinder in emergency position, so that this chamber is at atmospheric pressure. Then, as the equalizing piston returns to release, the cavity *b5* in the slide valve connects passages *12b* and *11* and the pressure in the application cylinder expands at once into the application chamber and reduces in pressure to about 15 pounds. The pressure in the brake cylinders is reduced to a corresponding pressure by the operation of the application piston and the slide valve *25*, and this pressure will be retained in the brake cylinders until the handle of the automatic brake valve is moved to running position.

This action does not occur when the controlled-emergency valve is in control position, because the application cylinder and the application chamber are connected in emergency position, so that the pressure in the application cylinder does not reduce when the brake valve is moved to release position. Therefore, the entire pressure is retained in the brake cylinders until the handle is moved to running position. The final release of the locomotive brake after an emergency application does not differ from the release after a service application, so that a

detailed explanation is unnecessary. The air from the application cylinder, or from the application cylinder and application chamber, depending on the position of the controlled-emergency valve, passes by way of the equalizing slide valve and the reduction-chamber cut-off valve to the application pipe and thence by way of the independent brake valve to the exhaust port of the automatic brake. The application piston and the exhaust valve then move to release position and the air is discharged from the brake cylinders as already explained.

INDEPENDENT BRAKE OPERATION

QUICK APPLICATION

78. A quick application of the independent brake is obtained by moving the handle of the independent brake valve to quick-application position, Plate *7*. Air at a pressure of 45 pounds is supplied by the reducing valve to passage *14*, from which it passes to chamber *X* above the rotary valve *154* of the independent brake valve. In quick-application position, the air from this chamber passes through port *t* in the rotary valve to passage *12* in the seat, and thence through the application pipe to the distributing valve, where it flows through passages *12* and *12c*, unseats the cut-off check-valve *96*, and flows through passage *12h* to passage *12b*. With the controlled-emergency valve piston in its upper or non-control position, the air flows from passage *12b* in two directions, namely, through the lower cavity in the controlled slide valve *163* to passage *12d*, thence to the application cylinder, and through cavity *b5* in the equalizing slide valve and passage *11* to the application chamber. The air, in flowing through cavity *b5*, also enters passage *10* and passes to the safety valve. Even though the controlled-emergency valve may be in control position, as shown in the lower supplemental view, the application of the brake will not be delayed by the choke *128*. The reason is that the air in flowing through passage *11* to the application chamber enters passage *11a* and then passes through the upper cavity in the delay slide valve to passage *12d* and thence to the application cylinder.

79. The air pressure that is then built up in chamber *A*, Plate 7, on the face of the application piston *23* forces the piston to the right where the exhaust slide valve *25* closes the brake-cylinder exhaust port; the pilot and the application valves next open and admit main-reservoir air to the brake cylinders, as described under Automatic Service Position. The brake-cylinder pressure developed is dependent on the pressure admitted to the application chamber and cylinder by means of the independent brake valve, and this in turn depends on the setting of the reducing valve, which is fixed at 45 pounds. The value of the cut-off spring *97* is about 5 pounds, so that the cut-off valve will be closed by the spring when a pressure of 40 pounds is built up. The remaining build-up of 5 pounds in the application chamber and cylinder then takes place from the application pipe through passage *12a*, the choke *127*, the cavity in the reduction-chamber cut-off slide valve *101*, and passage *12b*.

The maintaining check-valve *47*, Plate 1, prevents the air in passage *12* from entering the brake cylinders through the passages *9* and *9c*.

The cam on the independent brake valve opens the poppet valve *180* in quick-application position and exhausts the air from the controlled-emergency pipe at port *AT*, in the independent brake valve. This causes the controlled-emergency valve to assume non-control position owing to main-reservoir air in chamber *D*, as long as the handle of the brake valve is held in quick-application position. This position in combination with emergency position of the automatic brake valve will cause a much quicker and heavier application of the locomotive brake than otherwise if it is desired to operate the brake valves in this manner.

SLOW APPLICATION

80. The only operating difference between slow-application and quick-application position is in the size of the opening in the rotary-valve seat through which reducing-valve air is admitted to the application pipe. As shown in the supplementary view of the independent brake valve, Plate 7, passage *12* used in quick-application position is blanked by the rotary valve,

and port *t* registers with the slow-application port *12a*. This connection permits air to flow through choke *178 to passage 12*, thence to the application pipe and to the distributing valve, where it causes the brake to apply as described under Quick Application. The choke in the slow-application port *12a* imposes a slower build-up than is obtained in quick application.

LAP POSITION

81. Lap position, Plate 8, is used to hold the independent brake applied after the desired pressure has been obtained in the brake cylinder. In this position passages *12* and *12a* that lead to the application pipe are blanked by the rotary valve. After the brake valve has been placed in lap, the pressure in the brake cylinder increases until it is slightly higher than the pressure in the application cylinder, then the springs *44* and *45* return the pilot valve *40* and the application valve *37* to their seats, and the application piston *23* moves to the left until stopped by the resistance of the exhaust slide valve *25*. The slide valve blanks the brake-cylinder exhaust port and retains the air in the brake cylinder.

As long as the independent rotary valve is in lap position, the pressure in the brake cylinders will be maintained equal to that in the application cylinder by the maintaining feature of the application portion as already described under Automatic Service Position.

INDEPENDENT RELEASE

82. An independent application of the brake may be released by placing the handle of the independent brake valve in running position, provided that the automatic brake valve is also in running position. With both brake valves in running position, the application pipe is connected through passage *12*, Plate 2, ports *v* and *p* in the independent rotary valve, passage *3*, and cavity *F* to the automatic brake-valve exhaust port *Ex*. The air from the application cylinder *A* then escapes through passage *12d*, the lower cavity in the delay slide valve *163* to passage *12b*; also, the air in the application chamber escapes through passage *11*, cavity *b5* in the equalizing slide valve, to passage *12b*. From

this passage the combined flow of air escapes through a cavity in the reduction-chamber cut-off slide valve *101* to passage *12a*, through choke *127* and passage *12* to the application pipe, which is open to the exhaust port of the automatic brake valve. If the controlled-emergency valve is in control position as shown in the small supplemental view, the air from the application cylinder flows direct from passage *12d* through the upper cavity in the controlled-emergency valve to passages *11a* and *11*. Here the air combines with the flow from the application chamber which is passing through cavity *b5* in the equalizing slide valve *18*, passage *12b*, the cavity in the reduction-chamber cut-off slide valve *101*, passage *12a*, the choke *127*, and passage *12* to the application pipe.

When the pressure on the face of the application piston *23* is reduced, the piston and the slide valve move to the left, the exhaust ports uncover, and the brake-cylinder pressure is reduced at a corresponding rate.

If the handle of the independent brake valve is returned to lap before all of the pressure has escaped from the application cylinder, the application piston *23* will return to independent lap position, Plate 8, as soon as the brake-cylinder pressure is reduced a little below that remaining in the application cylinder, thus closing the exhaust port and holding the remaining pressure in the brake cylinder. In this way the release may be graduated as desired.

INDEPENDENT RELEASE AFTER AUTOMATIC SERVICE APPLICATION

83. If it is desired to release the locomotive brake after the brakes have been applied throughout the train by the automatic brake valve, the handle of the independent brake valve is placed in release position, Plate 9.

In this position the application pipe is connected through passage *12* in the pedestal, the port *x* in the rotary valve of the independent brake valve, to the exhaust port *Ex*. Also, air at reducing-valve pressure in chamber *X* above the independent rotary valve flows through port *y* to passage *6* in the brake-valve pedestal to the independent release pipe, and thence through passage *6* to chamber *E* on the face of the release piston *87*. The piston

is accordingly forced to the left and unseats the cut-off check-valve *96*, thereby establishing communication between passage *12h*, which connects with the application cylinder and the application chamber, and passage *12e*. This passage in turn connects directly with passage *12* and the application pipe, which is open to the exhaust through the independent brake valve as already explained. The air from the application cylinder now flows through passage *12d* and the lower cavity in the controlled-emergency slide valve *163* to passage *12b*, to which the application chamber is also connected by way of passage *11* and cavity *b5* in the equalizing slide valve. Air from these combined volumes then flows from the vertical passage *12b* through passage *12h*, past the unseated check-valve *96*, and through passage *12e* to passage *12* and the atmosphere at the exhaust port of the independent brake valve. With the controlled-emergency slide valve in control position, the upper cavity connects passage *12d* to the application cylinder with passages *11a* and *11* to the application chamber; the air then escapes through passages *12b*, *12h*, and *12e* to passage *12* and the application pipe, as already explained. During an independent release, the release choke *127* in passage *12a* of the distributing valve is by-passed because the air from the application cylinder and chamber does not pass from passage *12b* through the reduction chamber cut-off valve to passage *12a* with the cut-off piston in cut-off position, Plate 9. Therefore, a much faster release is obtained than when releasing in running position of the independent brake-valve.

Following the exhaust of air from the application pipe and from chamber *A* in front of the application piston, the brake-cylinder pressure in chamber *C* forces the application piston *23* and the exhaust valve *25* to release position, where the brake cylinders are opened to the exhaust. The warning port *t* in the rotary valve of the independent brake valve permits a steady blow of air to the exhaust port in release position, thereby warning the engineman of the position of the brake valve.

Releasing the locomotive brake under the conditions just mentioned does not imply that the brake will remain released, for after the brake-valve handle is returned to running position, the brake after a short interval will reapply. This is due to brake-

pipe leakage which is not supplied in lap position of the automatic brake valve. The equalizing portion then operates and causes pressure-chamber air to pass to the application chamber and cylinder and reapply the brake. To insure that the brake shall remain released it is necessary, therefore, to keep the independent brake valve in release position.

INDEPENDENT RELEASE AFTER AUTOMATIC EMERGENCY APPLICATION

84. The locomotive brake may be released by the independent brake valve after an automatic emergency application, in the same manner as after a service application. In the upper or non-control position of the controlled-emergency valve, Plate 9, the air from the application cylinder flows through passage *12d*, the lower cavity in the controlled-emergency slide valve *163*, and the passages *12b*, *12h*, *12c*, and *12* to the exhaust port at the independent brake valve. With the controlled-emergency valve in the lower control position as in the small supplementary view, the air in the application cylinder flows through passage *12d* to the upper cavity in the controlled-emergency slide valve *163*; also, the air in the application chamber which is now charged, flows through passage *11* and *11a* to the same cavity. From this cavity, the combined volumes of air flow through passage *12k*, past ball check *170*, and rubber-seated check-valve *167* to the passage shown, thus by-passing the choke *128*, thence to passages *12b*, *12h*, *12c* and *12* to the exhaust at the independent brake valve. The application portion of the distributing valve will now assume release position but the equalizing portion will remain in emergency position.

The handle of the independent brake valve must be held in release position to prevent a reapplication of the locomotive brake owing to the air that is being supplied to the application cylinder through the maintaining port in the rotary valve of the automatic brake valve in emergency position.

INDEPENDENT APPLICATION AFTER INDEPENDENT RELEASE

85. The locomotive brake may be reapplied after an independent release, when the automatic brakes are applied, by moving the handle of the independent brake valve to either slow-

or quick-application position, Plate 10. Air at reducing-valve pressure then flows from Chamber *X* through port *t* in the rotary valve to passage *12*, thence through the application pipe to the distributing valve. At the distributing valve the air flows through passages *12* and *12e*, unseats the cut-off check-valve *96*, and flows to passages *12h* and *12b*, cavity *b5* in the equalizing slide valve, and passage *11* to the application chamber.

From passage *12b*, air also flows through the lower cavity in the controlled-emergency slide valve *163* in its upper non-control position to passage *12d* and to the left of the application piston *23*, which is moved to open the application valve *37* and develop pressure in the brake cylinders as already explained. With the controlled-emergency valve in its lower or control position, the flow of air to the application cylinder is through cavity *b5* in the equalizing slide valve to passages *11* and *11a*, and the upper cavity in the controlled-emergency slide valve to passage *12d*. The pressure in the application chamber and cylinder is limited to 40 pounds by the cut-off check-valve spring *97* with the equalizing slide valve in lap position for the reason that passage *12a* is blanked by the reduction chamber cut-off slide valve *101*, and no further build-up of pressure can take place through choke *127*, as in release position of the equalizing slide valve.

BROKEN PIPES

86. Prevention.—Broken or leaky pipes can largely be prevented if the piping is well clamped and the different valves and their brackets are secured so as to prevent vibration. The brake cylinders should be applied to their brackets with fitted bolts so as to prevent any movement of the brake cylinders and consequent strain on the attached piping when the brakes are applied. Pipes usually break at the studs of the union connections or at the nipples used to connect the piping to the brake valves, distributing valve, and brake cylinders. A leak due to a slight crack in a stud or nipple is usually the first indication of a defect in these parts. Therefore, all studs and nipples should be regularly inspected for leakage and promptly repaired, thus avoiding the possibility of a pipe breaking on the road, as a

leak generally indicates a defective part that will finally break. Care should also be taken to see that all pipe joints are tight.

The escape of air from a broken pipe can be prevented in several ways. A union can be uncoupled and a short tapered plug of wood can be inserted in the inner end of the pipe, or a blind gasket of some material can be used, and then the union is connected up again. Should the safety regulations of the road permit, the pipe can be closed by driving in a plug of wood of such a length that it will hold in the pipe against the air pressure. The correct way to close a pipe is to unscrew it from the nearest coupling and apply a pipe plug, but this can be done only when a pipe wrench is available.

87. Main-Reservoir Branch Pipe.—If the branch pipe from the main reservoir to the distributing valve breaks between the main-reservoir pipe and the dirt collector, plug the pipe on the main-reservoir side of the break. If the break is between the distributing valve and the dirt collector, close the cut-out cock on the dirt collector. The locomotive brake is now inoperative but the train brakes can be operated as usual.

88. Brake-Pipe Branch Pipe.—Should the brake-pipe branch pipe to the distributing valve break, plug the end of the pipe that leads from the brake pipe. The locomotive brake cannot be operated by the automatic brake valve, but the brake can be operated by the independnt brake valve in the ordinary way, except that release position must always be used to release it. The operation of the train brakes is not affected. The foregoing also applies to a break in the section of the pipe between the branch pipe to the distributing valve and the branch to the automatic brake valve.

Should the brake pipe on the engine break back of the branch to the brake valve, the signal pipe can be used to convey the air to the brake pipe on the train. This can be done by using a combination hose to connect the brake-pipe hose at the pilot to the signal-pipe hose and then another such hose to connect the signal hose at the rear end of the tender to the brake-pipe hose on the first car. The broken brake pipe should be plugged toward the brake valve. A combination hose is one that is fitted

at one end with a coupling for the brake-pipe hose and at the other end with a coupling to fit the signal hose.

Should the brake pipe break in front of the branch to the brake valve and it is necessary to couple to a train ahead of the locomotive as in helper service, connect the brake hose at the rear of the tender to the signal hose with the combination hose. Then use another combination hose to connect the signal hose at the pilot to the brake hose of the car to which the locomotive is to be coupled.

If the brake pipe breaks under the tender, the signal pipe on the tender can be used as the brake pipe by using two combination hoses as just described.

89. Brake-Cylinder Pipe.—If the brake-cylinder pipe breaks next to the distributing-valve reservoir, close the cut-out cock in the main-reservoir branch pipe. The *locomotive brake* will then be inoperative. If the pipe breaks between the driver brake cylinders and the cut-out cock, close this cut-out cock. If the pipe breaks elsewhere, either plug the pipe or close a cut-out cock, depending on the location of the break.

90. Application Pipe.—If the application pipe breaks, the locomotive brake can be operated by the automatic brake valve, but the maintaining feature *in emergency* will be lost. A choke *34*, Plate 3, in the distributing valve restricts the leakage through the broken pipe when the brakes are applied, so that the main-reservoir pressure will not be affected.

91. Independent Release Pipe.—The only features lost when the independent release pipe breaks is the quick release of an independent brake application and the ability to release quickly an automatic brake application with the independent brake valve. Release in running position is not affected and no repairs are necessary.

92. Reduction-Limiting Reservoir Pipe.—If the reduction-limiting reservoir pipe breaks, move the first-service control cock to the "out" position. No further procedure is necessary.

93. Controlled-Emergency Pipe.—If the controlled-emergency pipe breaks, turn the handle of the controlled-emergency

cock to passenger position and so stop the loss of main-reservoir air. With the pipe broken, the controlled-emergency valve will move to non-control position.

94. Low-Pressure Operating Pipe to Governor.—If the low-pressure operating pipe to the governor breaks, place the handle of the automatic brake valve in lap position and plug the pipe toward the brake valve. The high-pressure head of the governor will then control the compressor.

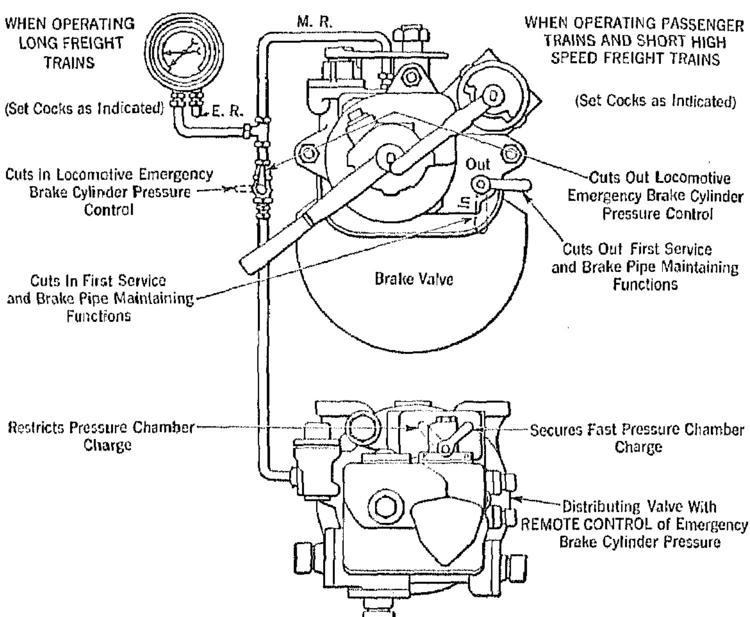


FIG. 27

95. High-Pressure Operating Pipe to Governor.—If the high-pressure operating pipe breaks, plug the pipe on the main-reservoir side of the break. This cuts out the high-pressure head of the governor, and the compressor must be throttled by hand in lap, service or emergency positions to prevent excessive main-reservoir pressure.

The steam throttle valve is in restricted position with this pipe broken, and the compressors will operate at about half speed.

The throttle valve can be adjusted for non-throttling position by removing the locking capscrew on the top of the valve and screwing the stop-screw down to its full travel.

96. **Equalizing-Reservoir Pipe.**—Should the equalizing-reservoir pipe break, plug the pipe toward the brake valve. Then to apply the brakes, move the automatic brake-valve handle to service position, next open the double-heading cock slowly, and

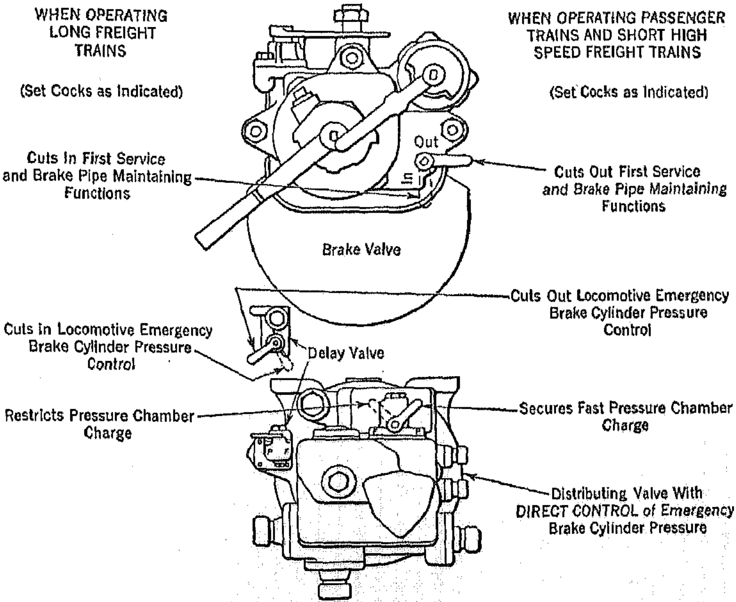


Fig. 28

after the desired brake-pipe reduction has been made, close the cock slowly to prevent a release of the head-end brakes.

To release the brakes, first move the handle of the automatic brake valve to release or running position, and then open the double-heading cock.

97. **Earlier Equipment.**—The piping diagram of the No. 8 ET equipment as first introduced is shown in Plate 12, and the cab cards are shown in Figs. 27 and 28.

The delay valve of the earlier equipment, which is called the controlled-emergency valve in the latest equipment, was con-

trolled in two different ways. With one installation this valve was controlled by a delay cock in the cab, and the control was said to be remote. With the other installation, the position of the delay valve was governed by a cock on the body of the valve, and the control was said to be direct. The terms *delay position* and *non-delay position* were applied to the positions of the delay valve, these terms having the same meaning as *controlled position* and *non-controlled position* with the later equipment.

When the control was remote and the delay valve was set in delay position, it was necessary to turn the cock in the delay pipe to non-delay position in order to obtain a quicker and heavier application of the locomotive brake in emergency, if such an application was desired. With the direct control, the delay valve could not be changed from a delay position to a non-delay position in the event of a condition arising that required the development of a high emergency brake cylinder pressure. With the equipment described in this lesson the control of the controlled-emergency valve is remote, and it is possible to change quickly from a control to a non-control position of this valve, should conditions warrant, by using quick-application position of the independent brake valve instead of turning the delay cock in the cab as with the earlier equipment.

98. Time and Pressure Data.—The time and pressure data listed below were obtained from tests made on a locomotive in road service with the brake equipment in good condition. The data may be considered as being fairly representative of the results that may be expected from the No. 8 ET equipment. However, the figures given may be found to vary somewhat, either one way or the other depending on how well the equipment is maintained.

In first-service position, 55 seconds was required to make a 20-pound reduction from a brake-pipe pressure of 110 pounds. After the reduction was made and the brake valve lapped, 44 seconds was required to reduce the pressure in the reduction limiting reservoir to zero through choke *120*. It required 100 seconds, with the foregoing reduction and with a brake-pipe pressure of 70 pounds, for the brake-cylinder pressure to build

up to 50 pounds. In first-service position a brake-cylinder pressure of 8 pounds was developed in the brake cylinders in 7 seconds with a 6-pound reduction.

In service position, 9 seconds was required to make a 20-pound reduction from a brake-pipe pressure of 70 pounds, and 8 seconds to make a 20-pound reduction from a brake-pipe pressure of 110 pounds. With both brake valves in running position, 20 seconds was required to reduce the brake-cylinder pressure from 65 pounds to zero, and 15 seconds to reduce the pressure from 45 pounds to zero. It should be remembered that the air was passing through choke *127* at this time.

With the controlled-emergency valve in non-control position, 1 second was required to develop a brake-cylinder pressure of 65 pounds in an emergency application; with the valve in control position, 35 seconds was required to develop a brake-cylinder pressure of 50 pounds and 55 seconds to obtain a pressure of 65 pounds.

With an independent release, 8 seconds was required to reduce the air in the brake cylinder from 65 pounds to zero, the air in the application cylinder and chamber now exhausting through the cut-off check-valve. In this case, the air does not pass through choke *127*.

In independent slow-application position, 9 seconds was required to develop a brake-cylinder pressure of 50 pounds, and in independent quick-application position 4 seconds was required to develop a pressure of 50 pounds in the brake cylinders.

A pressure of 21 pounds against the release piston was required to open the cut-off check-valve and release a brake cylinder pressure of 65 pounds.

INSTRUCTIONS FOR MAKING STOPS WITH AUTOMATIC BRAKE

99. Specific instructions for stopping passenger trains and freight trains are usually issued by each railroad to cover its own recommended practice in accordance with local operating conditions. The following general instructions for stopping trains are given by the Westinghouse Air Brake Company.

Service Application

Passenger Service.—To make a smooth and accurate *two-application passenger stop*, make the first application sufficiently heavy (using a split reduction) to bring the speed of the train down to about 15 miles per hour at a convenient distance from the stopping point, then release and re-apply as required to make the desired stop, the first release and the final release being made as explained under Release.

To make a *graduated release stop* (with trains having graduated-release equipment), make the brake application sufficiently heavy (using a split reduction) to bring the speed of the train down to 12 or 15 miles per hour about 400 feet from the stopping point, and release as explained under Graduated Release.

The *split reduction* consists of dividing into two brake-pipe reductions, with a short interval between, a number of pounds total reduction which, if made in one continuous reduction, might cause harsh slack action. As an example, if a total reduction of 15 pounds is required, draw off 7 pounds, wait until the first slight run-out shock is felt (usually when the brake-valve exhaust stops), then add 8 pounds additional reduction.

Freight Service.—The smoothest stop with automatic brakes is by the use of first-service position only. With this manipulation the handle is left in first-service position until the train is within 40 feet of the stopping point when an additional brake-pipe reduction of 6 to 8 pounds is made by advancing the handle to normal service position. This second reduction should be so timed that air will be discharged from the brake-valve exhaust as the locomotive comes to a stop, as under this condition a greater retarding force will be built up on the head end than toward the rear and thus prevent any run-out of slack that otherwise might take place due to the locomotive influence.

Another method by which the first-service position may be used when a shorter service stop is required, is to use first-service position for not less than 25 seconds after which the brake-pipe reduction is continued by advancing the brake-valve handle to normal service position and continuing the reduction to a degree that will bring the train to a stop at the objective point. A final brake-pipe reduction of 6 or 8 pounds is again made within 40 feet of the stop for the same reason just referred to.

To obtain the shortest practical service stop with long modern trains, it is considered good practice to make but one application, divided into three reductions, all of which are made in normal *service* position of the brake valve. The first reduction of brake-pipe pressure should be an amount that will apply the brakes on a train only to a degree that will prevent harsh slack action. Following the first relatively light brake-pipe reduction, time enough should be allowed for the train slack to be

adjusted, after which a further brake-pipe reduction is made. This reduction should be sufficiently heavy to prevent passing the objective point. Finally within 40 feet of this stop an additional brake-pipe reduction of 6 to 8 pounds should be made.

Release

Passenger Service—Direct Release.—In making the first release of a two-application stop the brake-valve handle should be moved to *release* position and then quickly back to *running* position, where it should be allowed to remain for an instant, (1st, to permit the pressure in the equalizing reservoir and brake pipe to equalize, and 2nd, to release part of the driver brake-cylinder pressure) then moved to *lap* position and from there to *service* position as required. In passenger service the time the handle is in *release position should be only momentary* but the time in *running* position should be governed by the conditions existing for each particular case, such as the length of train, kind of reduction made, time available and so on.

In making the final release of a two-application stop, with short trains, release shortly before coming to a standstill by moving the handle to *release* position and immediately back to *running* position, and leave it there. With long trains, the brakes should, as a rule, be held applied until the train stops.

The release after a one-application stop should be made in the same manner as the *final* release of a two-application stop.

Passenger Service—Graduated Release.—This method consists of releasing the train brakes in steps or graduations, as can be done with graduated release equipment, but not with the older (*PM*) equipment. With the brakes applied and the brake-valve handle in *lap* position, graduated release is accomplished by moving the handle to *release* or *running* position and back to *lap*, leaving it in one of these positions long enough to increase brake-pipe pressure throughout the train enough to move the universal or triple-valve parts to release position and start the exhaust of brake-cylinder pressure. When the brake-valve handle is moved back to *lap* position, the universal or triple-valve parts will also move back to lap position, thereby cutting off the flow of brake-cylinder pressure to atmosphere.

With the first-service position feature of the automatic brake-valve cut-out (the handle of the control cock in non-operative position) this brake-valve handle position becomes a "lap" position and may be used as such when making a graduated release stop. As this position is closer to *running* and *release* positions than the normal *lap* position, the amount of brake-valve handle movement is less and is more convenient than when normal *lap* position is used.

For the first graduated release, move the brake-valve handle to *release* position for a second or two, then back to *lap*. Make the succeeding

graduations by moving the handle to *running* position and back to *lap*. Use *release* positions for the final release. By two or three partial, or graduated, releases, so complete the stop as to have little or no holding power when the train comes to rest, this depending upon the length of train or grade.

Freight Service.—Under present conditions it is, as a rule, safest to come to a stop before releasing the brakes on a freight train, especially a long one, rather than attempt to release at low speed. However, if conditions permit the release while in motion, the brake-valve handle should be moved to *release* position and held there long enough to move as many of the triple valves to release position as possible without unduly overcharging the head end of the train (the time in *release* position should be governed by the length of train, amount of reduction made, etc.) and returned to *running* position to release the locomotive brakes and complete the recharging of the auxiliary reservoirs. A few seconds after such a release, particularly on long trains, it is necessary to again move the handle to *release* position and quickly back to running position to "kick off" any brakes at the head end of the train that may have reapplied due to their auxiliary reservoirs having been slightly overcharged.

INDEPENDENT BRAKE

When handling long trains of cars, in road or switching service, the independent brake should be operated with care, to prevent damage to cars and lading, caused by running the slack in or out too hard. In cases of emergency arising while the independent brake is applied, apply the automatic brake instantly. The safety valve will restrict the brake-cylinder pressure to the proper maximum.

The brakes on the locomotive and on the train may be alternated in heavy-grade service where conditions (such as short, steep grades or where grade is heavy and straight for short distance) require, to prevent overheating of driving-wheel tires and to assist the pressure-retaining valves in holding the train while the auxiliary reservoirs are being recharged. This is done by keeping the locomotive brakes released by the use of the independent brake valve when the train brakes are applied, and applying the locomotive brakes just before the train brakes are released, and then releasing the locomotive brakes after the train brakes are re-applied.

Care and judgment should always be exercised in the use of driver brakes on grades to prevent overheating of tires.

If, when the locomotive is coupled to a train, the locomotive brake re-applies after being released, make a "kick off" with the automatic brake valve by moving the handle quickly from *running* position to *release* and return to *running.* The reason for the re-application is that the pressure chamber of the distributing valve is charged higher than the brake pipe, causing the equalizing valve to move into service and then

service lap position, closing the connection between the application cylinder and application pipe and preventing the release of application cylinder pressure with the brake valves in running position. Releasing with the independent brake valve in release position under these conditions will release the locomotive brake but will not insure against a reapplication.